

**US Army Corps  
of Engineers  
Savannah District**

**Contract Number  
DACA21-96-D-0010  
Delivery Order 0002**

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## **REDSTONE ARSENAL EXTENDED PUMP TEST AT RSA-10**

### **Work Plan**

**DRAFT DOCUMENT**

**February 1996**

# REPORT DOCUMENTATION PAGE

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## 1.0 INTRODUCTION

ICF Kaiser Engineers, Inc. (ICF KE) has been contracted by the U.S Army Corps of Engineers, Savannah District, to install and operate a groundwater extraction and treatment system as an extended pump test for RSA-10 at Redstone Arsenal, Alabama. This work is being performed under Contract DACA21-96-D-0010, Delivery Order 0002. The purpose of this action is to extract trichloroethylene-contaminated groundwater using extraction wells screened in the fractured bedrock, reduce the concentrations of volatile organic compounds (VOCs) in the aqueous stream using an air stripper, and discharge the effluent into the facility sewer system.

This work is being performed for the U.S. Army Missile Command environmental office at Redstone Arsenal, and under the purview of the U.S. Environmental Protection Agency, Region IV, and the Alabama Department of Environmental Management.

This extended pump test work plan is divided into six sections, as follows:

### Section 1 - Introduction.

Section 2 - Site Background. The site history is summarized in this section. Brief descriptions of the site geology and hydrogeology, and an assessment of the extraction wells that will be used in this remedy, are also provided.

Section 3 - Description of Groundwater Extraction and Treatment System. The design rationale and parameters for the groundwater extraction and treatment system are provided. The expected influent and effluent concentrations of volatile organic compounds are presented. Drawings showing the equipment layout, process flow diagram, and the piping and instrumentation diagram are provided in the appendices.

Section 4 - Project Schedule. The schedule is presented in this section and as a Gantt chart in Appendix A.

Section 5 - Permit Requirements. The permits requirements that will be met during construction and operation of the treatment system are listed.

### Section 6 - References

## **2.0 SITE BACKGROUND**

RSA-10 is a 68.5-acre landfill located near the geographic center of Redstone Arsenal, Alabama. The landfill is bordered on the north by a wooded area; to the east by a closed landfill (Area Q-3); to the south by the Wheeler National Wildlife Refuge and the floodplains of Huntsville Spring Branch; and to the west by the NASA test area (Figure 1). RSA-10 is composed of a DDT-contaminated soil and sediment landfill (capped but not lined), a waste oil pit area (not capped or lined), closed landfill trenches in which household waste, paper products, waste oil, and construction debris have been disposed (covered with native soil but not lined), and an active sanitary landfill in which household waste, waste oil, hospital infectious waste, construction debris, asbestos, and ash from incinerated paper have been disposed. At present, the active portion of the landfill receives only construction/demolition wastes. The active sanitary landfill is permitted and operated as a solid waste disposal facility under ADEM regulations (Permit No. 45-03R).

Numerous environmental studies have been conducted at RSA-10 since 1977. The results of recent studies by P.E. Lamoreaux and Associates (PELA) in 1988 and Geraghty and Miller (G&M) in 1991 indicate that the groundwater underlying and downgradient of the site is contaminated with volatile organic compounds (VOCs), primarily trichloroethylene (TCE). Semivolatile organic compounds (SVOCs) have also been detected at low concentrations in groundwater samples collected from several monitoring wells at RSA-10.

To further evaluate the extent of groundwater contamination, a total of six extraction wells were installed along the southern edge of the landfill in 1995. These wells were screened within the limestone bedrock aquifer, and groundwater samples were collected from these wells. The results of analysis of these groundwater samples indicate that the groundwater near extraction wells EX-01 and EX-02 is contaminated with approximately 1,000  $\mu\text{g/L}$  of VOCs (the well locations are shown in Figure 1 in Appendix A). To address the contamination in groundwater in this area and to provide for limited hydraulic control of the bedrock aquifer, the Army has elected to pump these two extraction wells and treat the groundwater.

## **2.1 SITE GEOLOGY**

RSA-10 is underlain by a residuum overburden which is, on average, 90 feet thick. The overburden is composed of fine to medium-grained sands with intermittent clay and silt layers of variable thickness. The deeper residuum layers also contain weathered limestone, limestone gravel, and chert lenses. A rubble zone, composed of limestone gravel, is present directly above bedrock, but is not continuous throughout the site. Underlying the residuum is the Tuscumbia limestone bedrock.

## **2.2 SITE HYDROGEOLOGY**

The site hydrogeology is characterized by a two-layer system that is hydraulically connected. Groundwater flow occurs through the intergranular porosity in the overburden, and preferential flow pathways are likely due to grain-size variations of the insoluble residues produced from the dissolution of the limestone bedrock. In general, groundwater flow in the residuum follows surface water divides. Locally, groundwater in the residuum is likely discharging to the deeper limestone unit.

The limestone bedrock aquifer exhibits secondary porosity in the form of solutionally enlarged fractures, bed partings, and joints (i.e., a karst aquifer). Previous studies at the site (PELA, 1988) have suggested the possibility of artesian conditions in this unit, and this has been confirmed by the work

performed by Foster Wheeler (Foster Wheeler, 1995). Porous flow approximations are not valid for this unit.

Water level measurements collected in the monitoring wells in 1991 have been used to evaluate the groundwater flow directions in the residuum and bedrock aquifers. The potentiometric contours indicate that in the shallow residuum, groundwater flows primarily toward the south and likely discharges to the wetland in the Wheeler National Wildlife Refuge. On the eastern side of RSA-10, groundwater also flows toward the drainage between RSA-10 and Area Q-3, which indicates that a drainage divide is present in this area and groundwater most likely discharges to the drainage ditch. Some percentage of the groundwater in the overburden is discharging to the limestone aquifer.

The limited data available for the groundwater gradients in the bedrock aquifer indicate that groundwater flow is toward the southeast.

## **2.3 ASSESSMENT OF THE EXTRACTION WELLS**

Both EX-01 and EX-02 are constructed of approximately 90 feet of stainless steel 6-inch casing and 60 feet of stainless steel screen. The screened intervals are entirely within the fractured Tusculumbia limestone bedrock aquifer. The boreholes for the wells were drilled using air rotary methods, and limited well development (on the order of 4 hours per well) was performed.

A 20-hour pump test was performed in well EX-01. During the pump test, 70 feet of drawdown resulted from a pumping rate of 16 gpm, and it was concluded that only pseudo steady-state conditions were achieved. Drawdown in EX-01 was 11.2 feet at the end of the test. Therefore, it appears that the fractured intervals in which these two wells are screened are in hydraulic communication.

A specific capacity test was performed for EX-02, which involved the pumping of 1,000 gallons of water at a steady flow rate of 5 gpm. The drawdown at the end of the test was 55 feet.

The large amounts of drawdown observed during the aquifer tests indicate that it is unlikely that the wells will sustain pumping rates of 15 gpm (EX-01) and 5 gpm (EX-02) for extended periods. Therefore, the groundwater extraction and treatment system has been designed to allow flexibility in the flow rate and protection of system components during well recharge intervals.

Of the six extraction wells installed by Foster Wheeler, these two wells were selected for use in this extended pump test due to the relatively high levels of TCE detected in the respective groundwater samples. The expected influent concentrations to the groundwater treatment system are discussed in more detail in the next section.

### **3.0 DESCRIPTION OF GROUNDWATER EXTRACTION AND TREATMENT SYSTEM**

A conceptual design has been completed for a groundwater extraction, treatment, and discharge system to be installed at RSA-10. This section of the extended pump test work plan presents the conceptual design details which will be used to develop the full engineering design and specifications for construction of the extraction-treatment-discharge system to impose hydraulic control and to reduce the dissolved TCE concentrations in groundwater at RSA-10. References will be made throughout the descriptions to the design drawings included in Appendix A. Also relevant to the following discussion are select design calculations included in Appendix B, and the major equipment specifications included in Appendix C.

#### **3.1 ANTICIPATED EXTRACTED GROUNDWATER CONTAMINANT CONCENTRATIONS**

Groundwater data obtained from samples collected during pumping tests conducted in March/April 1995 for extraction wells EX-01 and EX-02 were used to anticipate the influent groundwater contaminant concentrations. The estimated concentration of dissolved TCE in groundwater ranged from 940 to 1600  $\mu\text{g/L}$ ; however, a conservative estimate of dissolved-phase TCE concentration of 2,500  $\mu\text{g/L}$  is used as a basis for air stripper design. Although TCE is the primary constituent of concern at RSA-10, other organic constituents detected in the groundwater during the March/April 1995 pumping tests are toluene (ranging from 2 to 85  $\mu\text{g/L}$ ) and 1,1-dichloroethene (ranging from 3 to 6  $\mu\text{g/L}$ ). The expected influent contaminant concentrations are listed in Table 3-1 for the major constituents of concern. Also included in this table is the Toxicity Characteristic Regulatory Level for the contaminants. The facility POTW will accept contributions to the sewer system at concentrations below these levels and for a total daily flow of less than 25,000 gallons per source.

#### **3.2 OVERVIEW OF TREATMENT SYSTEM DESIGN**

The extended pump test system for RSA-10 is designed to include automatically controlled extraction of TCE-impacted groundwater, treatment of the extracted groundwater using air stripping, and discharge of treated groundwater via an existing sewer manhole to an existing POTW. The pumping scheme is being employed in an effort to provide an interim method of extracting and treating dissolved-phase TCE. The system design includes remote alarm notification in case of system shut-down, automatic controls for system operation, and controls for individual component and full system shut-off.

#### **3.3 EQUIPMENT COMPOUND AND TRENCHING LOCATION RATIONALE**

The groundwater remediation system for RSA-10 consists of an extraction and treatment system. The remediation system location plan is shown in Drawing 1 of Appendix A. Two existing extraction wells, located near the southwestern boundary of RSA-10, are to be used to remove the groundwater from the subsurface. The groundwater treatment equipment is to be housed in a temporary equipment shed. Access into the equipment shed is to be provided by one double swing door. The equipment shed is to be situated near an existing RSA-10 area dirt access road. The placement of the equipment shed near the dirt access road is designed to allow easy traffic access to the treatment system. The equipment shed is oriented such that trench piping lengths for both the influent groundwater and the treated effluent are minimized. Extraction wells, EX-01 and EX-02, are to be connected to the equipment shed via below-grade utility trenches containing buried high-density polyethylene (HDPE) process piping, galvanized steel electrical conduits, and control wire conduits. The location of the trench containing buried treated water

**TABLE 3-1  
ANTICIPATED INITIAL INFLUENT CONTAMINANT CONCENTRATIONS**

<b>Constituent</b>	<b>Expected Influent Concentration (µg/L)</b>	<b>Toxicity Characteristic Regulatory Level (µg/L)</b>
<b>Organic Compounds</b>		
1,1-Dichloroethene	6	700
Toluene	85	NTG
Trichloroethene	2,500	500
<b>Inorganic Compounds</b>		
Iron	80	NTG
Manganese	60	NTG
Zinc	30	NTG
Total Suspended Solids	< 10 mg/L	< 240 mg/L
Carbonate Alkalinity (as CaCO <sub>3</sub> )	< 350	NTG

Toxicity Characteristic Regulatory Level from 40 CFR 261.24, Table 1.  
NTG= No treatment goal for this constituent.

conveyance piping is selected to circumvent known buried structures<sup>1</sup> within the RSA-10 area and to minimize the length of trenching needed to access the sewer tie-in connections for discharge of the treated water to the POTW.

The existing RSA-10 dirt access road near which the equipment shed is to be situated also provides access to the two existing extraction wells (EX-01 and EX-02). Therefore, the wells can be maintained when necessary.

### 3.4 GROUNDWATER EXTRACTION SYSTEM

The groundwater extraction system is to consist of two existing groundwater extraction wells EX-01 and EX-02 located near the southeastern boundary of RSA-10 as shown in Drawing 1 of Appendix A. The existing wells (EX-01 and EX-02) are 6 inches in diameter and the well screens and casings are constructed of stainless steel. The approximate depth of each well is 150 feet below ground surface. Well EX-01 is to extract groundwater at an average flow rate of 15 gpm. Well EX-02 is to extract groundwater at an average flow rate of 5 gpm.

Based on system friction losses, a 4-inch diameter, 1-horsepower (hp) submersible pump (P-100) installed in Well EX-01 is to be rated for a capacity of 15 gpm at a minimum of 180 ft total dynamic head (TDH) and constructed of stainless steel. Similarly, a 4-inch diameter, 1/2-horsepower (hp) submersible pump (P-200) installed in Well EX-02 is to be rated for a capacity of 5 gpm at a minimum of 180 ft TDH and constructed of stainless steel. Friction loss calculations are included in Appendix B. The material of construction of the mechanical seals on the submersible pump are to be chemically compatible with the TCE constituents present in the groundwater.

The submersible pump is to contain the starting components integrally with the motor assembly. A water-tight junction box and an on/off disconnect switch installed at the well head is to connect the pump to power from the equipment shed control panel. Hand-off-automatic switches for the submersible pumps which control their operation in response to sensor input from the downhole groundwater level probes is to be housed in the control panel located in the interior of the equipment shed. The probe sensors are to be placed to ensure that the pumps are adequately submerged before commencing pumping operations and that the pump cycling frequency is not excessive.

The submersible pump is to be suspended above the base of the well and supported by a steel safety cable hanging from a support flange/well seal at the top of the well casing.<sup>2</sup> A sufficient length of coiled steel safety cable shall be incorporated to allow the submersible pump to be easily removed from the well for periodic servicing. Flexible pump discharge hose is to be connected from the pump discharge to the top of the well where a quick disconnect switch is to be used to connect the hose to the HDPE groundwater conveyance piping. Each of the HDPE groundwater conveyance pipes are to be connected to the equipment building via utility trenching (as shown in Drawing 1 of Appendix A). The groundwater extraction utility trench is to also contain (2) sealed 3/4-inch diameter galvanized steel electrical conduits and one conduit for the power supply to the submersible pump and the other conduit for the groundwater level sensors. The sealed power supply conduits originate from the well head as follows: (1) at a

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<sup>1</sup>The conceptualized location of the trench containing treated water conveyance piping was developed without the availability of site utility, structural, and landfill maps and may be subject to change when additional information becomes available.

<sup>2</sup>The rated break strength of the steel safety cable supplied should be sized appropriately to handle the total hanging weight of the pump system.

connection to a water-tight junction box and electrical disconnect switch; and (2) where the control wiring associated with the level sensing probes are terminated.

### 3.5 GROUNDWATER TREATMENT SYSTEM

Both of the HDPE groundwater pipes originating from EX-01 and EX-02 are to extend below grade via individual groundwater extraction utility trenches to stub-up in the equipment shed interior. Inside the equipment shed, the individual groundwater extraction pipes are to be fitted with an isolation valve prior to being manifolded to a 2-inch diameter header constructed of Schedule 40 PVC. The above-ground piping located in the equipment shed is to be constructed of Schedule 40 PVC pipe. The 2-inch diameter header is to include a flow quantity totalizer, an instantaneous flow meter, a pressure indicator, and a sample port to allow for system monitoring.

As illustrated in the process flow diagram and the piping and instrumentation drawing (P&ID), Drawings 2 and 3 of Appendix A, the groundwater treatment system is to include a bypass filter<sup>3</sup>; an air stripper/blower system; a discharge transfer pump; and associated controls. Appendix C includes equipment manufacturer's literature on select equipment components.

The extracted groundwater is to be introduced to a low profile air stripping system for organics treatment where dissolved-phase volatile contaminants in the groundwater are to be transferred to the vapor phase. The mass transfer process is accomplished by operating the low-profile air stripper in a counter-current mode, by which groundwater enters the air stripper from the top and cascades down through the unit, while air is forced using a blower counter-currently from the bottom and ejected from the top. The forced air is supplied to the air stripper by a 3-hp, 230V, single phase, blower capable of approximately 300 cubic feet per minute (cfm) against a discharge pressure of 14 inches of water. Effluent air from the low-profile stripper containing VOCs will be vented directly to the atmosphere from a discharge stack.<sup>4</sup>

Table 3-2 provides additional details on the air stripper specification. Based on the expected influent TCE concentration in groundwater of 2,500  $\mu\text{g/L}$ , the proposed low profile air stripper is designed to achieve a 99.91 percent removal efficiency. TCE concentrations in the treated water effluent is to be reduced to 3  $\mu\text{g/L}$ . The vapor-phase TCE mass flow rate in the air stripper off-gas is expected to be 0.0374 pounds per hour. Assuming a temperature of 60°F and an air flow rate of 300 cfm, the concentration of TCE in the stack discharge is calculated to be 0.37 parts per million volume (ppmv). The velocity of the stack discharge is 1,530 cfm based on an air discharge duct diameter of 6-inches and an air flow rate of 300 cfm. Drawing 2 of Appendix A also presents process flow data on the various constituents detected in the groundwater.

Level sensors within the air stripper unit are to monitor the level of water being treated by the stripper, and control the action of the extraction pumps. Treated groundwater exiting the air stripper is to be pumped using the discharge transfer pump in response to a liquid level switch which monitors the

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<sup>3</sup> Based upon available data, it does not appear that pre-filtration of the extracted groundwater will be required. However, extracted groundwater entering the treatment system may be optionally routed through a filter to eliminate excess suspended solids, if necessary, when purge water from the remedial investigation tank is pumped into the treatment system. The filtration system may also be incorporated if suspended solids prove to adversely affect the system by reducing treatment efficiencies and increasing downstream operation and maintenance costs.

<sup>4</sup>As shown in Table 3-2, the air discharge duct is 6 inches in diameter and is set at a height of 10 feet.

liquid level in the sump tank integral to the air stripper. The effluent is to be pumped to the sewer via a utility trench containing HDPE conveyance piping in compliance with POTW requirements.

### **3.6 SYSTEM CONTROL AND TELEMETRIC MONITORING**

An indoor process control and electrical NEMA 4X (splash-proof) panel is to house the motor starting components, motor protectors, circuit breakers/power distribution system, programmable logic controller, modems, control logic interconnections, visual alarms to indicate system malfunction, and telemetry system. Control panel ratings are to meet the requirements of local fire codes.

As shown in the P&ID (Drawing 3 of Appendix A), the groundwater extraction and treatment system controls are to include: a flow quantity sensor and indicator, an instantaneous flow indicator, and a pressure indicator on the inlet manifolded piping; a high-level switch and alarm and a temperature indicator in the air stripper; a high-pressure switch and alarm and a low-flow switch and alarm at the air stripper blower; a flow quantity sensor and indicator, an instantaneous flow indicator, and a pressure indicator on the effluent discharge piping. Drawing 4 presents the associated legend for the P&ID.

Treated water leaving the air stripper is to be pumped to the sewer manhole using the discharge transfer pump. Should the volume of accumulated water in the air stripper sump tank reach a critical level before it is pumped to the sewer, a high-high-level switch in this tank is to be actuated which will terminate operation of the extraction well submersible pumps, and locally and remotely report an alarm condition to the RSA-10 office. Therefore, if process flow is impeded by a failed transfer pump or control system to prevent overflow of untreated groundwater. A high-low-level switch in the air stripper sump tank is to both enable or disable the discharge transfer pump operation. Similarly, when the low-flow switch is actuated downstream of the air stripper blower, both of the extraction well submersible pumps operations are to be discontinued to ensure adequate groundwater treatment efficiency. A high-pressure switch downstream of the air stripper blower is to be used as an early warning of plugging/fouling of the air stripper.

Flow quantity sensors and indicators and an instantaneous flow indicators are to be located in the inlet piping, in the effluent discharge piping to the sewer to measure totalized and instantaneous flows to allow local monitoring of the volume of water extracted, treated, and discharged.

A telephone line/telephone service is to be provided to the equipment building to allow for autodialling for remote notification of system shut-down or alarm. The telemetry unit is to be programmed to notify the operator of the alarm conditions described above.

Additional control panel features are to include elapsed time meters for all electrically operated components (solenoids and motors) and lightning protection for all inputs and outputs from the control panels (telephone lines, control lines, and power supply lines). The elapsed time meters are to track cumulative time of operation of the monitored components to evaluate component performance (duty life) and to schedule planned maintenance. The lightning protection is to minimize damage to system components that may result from power surges.

### **3.7 EQUIPMENT SHED LAYOUT**

The layout of the equipment shed is to provide weather protection and adequate access to the process equipment for maintenance and monitoring. The 10' wide x 15' long equipment shed is to be equipped with sound dampening materials to reduce equipment operating noise and for weather protection and one double swing door. The equipment shed is to house the filter, the low-profile air

**TABLE 3-2**  
**AIR STRIPPER SPECIFICATION DETAILS**

Description	Low profile shallow tray air stripper Model 2331-P constructed of linear low density polyethylene. Three tray unit.
Blower Description	Forced air draft blower, 3 HP, 1/60/230 VAC, 300 cfm at 14 IWC
Air Stripper Dimensions	6'0" H x 8'0" L x 4'5" W
Air Stripper TCE Efficiency	99.91 %
Height of Air Discharge Duct	10'0"
Air Discharge Duct Diameter	6-inches
Temperature of Air Leaving Discharge Duct	60°F
Velocity of Air Leaving Stack	1,530 feet per minute (ft/m)
TCE Stack Discharge in Air Duct	0.0374 pounds per day
Concentration of TCE in Stack Gas	6.2 parts per million volume (ppmv) at 300 cfm
Concentration of TCE in Water Effluent	3 µg/L

stripper and blower, the air stripper transfer pump, the discharge tank, the discharge transfer pump, instrumentation and controls. The equipment shed is to be anchored to a concrete pad constructed near the existing dirt access road for structural support for the duration of the remedial activities. The equipment shed is to include a heating and lighting systems. Exposed above-ground piping, if needed, is to be electrically traced for freeze protection.

### **3.8 SYSTEM OPERATION AND MAINTENANCE**

Operation and maintenance (O&M) of the installed system will include scheduled visits to complete routine preventive maintenance and monitoring tasks. There is a possibility that unscheduled visits to conduct repairs and system adjustments may be required. Scheduled preventative maintenance and inspections will be performed to help ensure efficient, long-term operation of system components. After installation, ICF Kaiser personnel will spend a total of 50 scheduled days annually on the site to perform O&M and environmental sampling (discussed in Section 3.9). During the routine site visits, the remediation equipment will be visually inspected, pressure and flow measurements will be taken and recorded, and manifold valving may be adjusted, as appropriate.

Disposal of bag filters, if required, will be coordinated, scheduled and completed in order to coincide with routine site visits where reasonably possible. System electrical operating parameters, and system integrity inspections will be conducted quarterly and are to coincide with other site visits or inspections. Routine equipment maintenance including the cleaning of the air stripper, changing of lubricating oil and cleaning/replacement of filters are to be completed during regularly scheduled site visits and are in general accordance with equipment manufacturer's recommendations.

### **3.9 SYSTEM MONITORING AND REPORTING**

Monitoring of the installed system will include scheduled visits in conjunction with O&M activities to complete environmental sampling tasks. Twice per month, an effluent water sample will be collected and analyzed for VOCs using SW-846 Method 8240. These effluent data, together with the totalized flow reading for the two-week period, will be provided to the environmental office at Redstone Arsenal.

#### **4.0 PROJECT SCHEDULES**

The planned schedule of activities leading to remediation system operation and maintenance are shown in Figure 5 (Appendix A). Equipment procurement and assembly will occur over an estimated 8-week period. On-site construction work, including the installation of subsurface trenching/piping and utility connections, will begin prior to shipment of the assembled remediation equipment to the site and will terminate before the equipment has arrived at the site. Start-up and trouble-shooting activities are to be completed within two weeks.

## **5.0 PERMIT REQUIREMENTS**

Using the air emissions data provided in Table 3-2 of this work plan, the environmental office of Redstone Arsenal will obtain any necessary air permits.

The necessary excavation permits will be obtained from the facility prior to trenching operations. Clearance of buried utilities will be performed by facility personnel.

Treated effluent will be discharged into the sanitary sewer system; eventual treatment and discharge will occur under the facility's existing NPDES permit. Treated effluent from the extended pump test will be non-hazardous (i.e., the concentrations of contaminants will be less than their respective Toxicity Characteristic Regulatory Level established in 40 CFR 261.24.) The flow rate will be controlled such that the daily flow into the sewer system from the air stripper will not exceed 25,000 gallons.

## **6.0 REFERENCES**

- Foster Wheeler Environmental Corporation (Foster Wheeler), 1995. An Informal Report: Hydrologic Considerations and Recommendations for the Interim Corrective Measure Design, RSA-10, Redstone Arsenal, Alabama. June 7, 1995.
- Geraghty and Miller, Inc., 1991. Identification and Evaluation of Potential Solid Waste Management Units and Areas of Concern (AOCs) at Redstone Arsenal, Alabama. February 1991.
- Lamoreaux, P.E. and Associates (PELA), 1988. Remedial Investigation Engineering Report for Redstone Arsenal, Alabama. Unit 1 - DDT and Sanitary Landfills and Unit 2 - Open Burn/Open Demolition Area. Final Document. September, 1988.

# EXTRACTION AND TREATMENT SYSTEM

PREPARED FOR:

## U.S. ARMY CORPS OF ENGINEERS

RSA-10 INTERIM GROUNDWATER REMEDY  
REDSTONE ARSENAL, ALABAMA

PROJECT NO. 66942-001-00

FEBRUARY 13, 1996

### SHEET INDEX

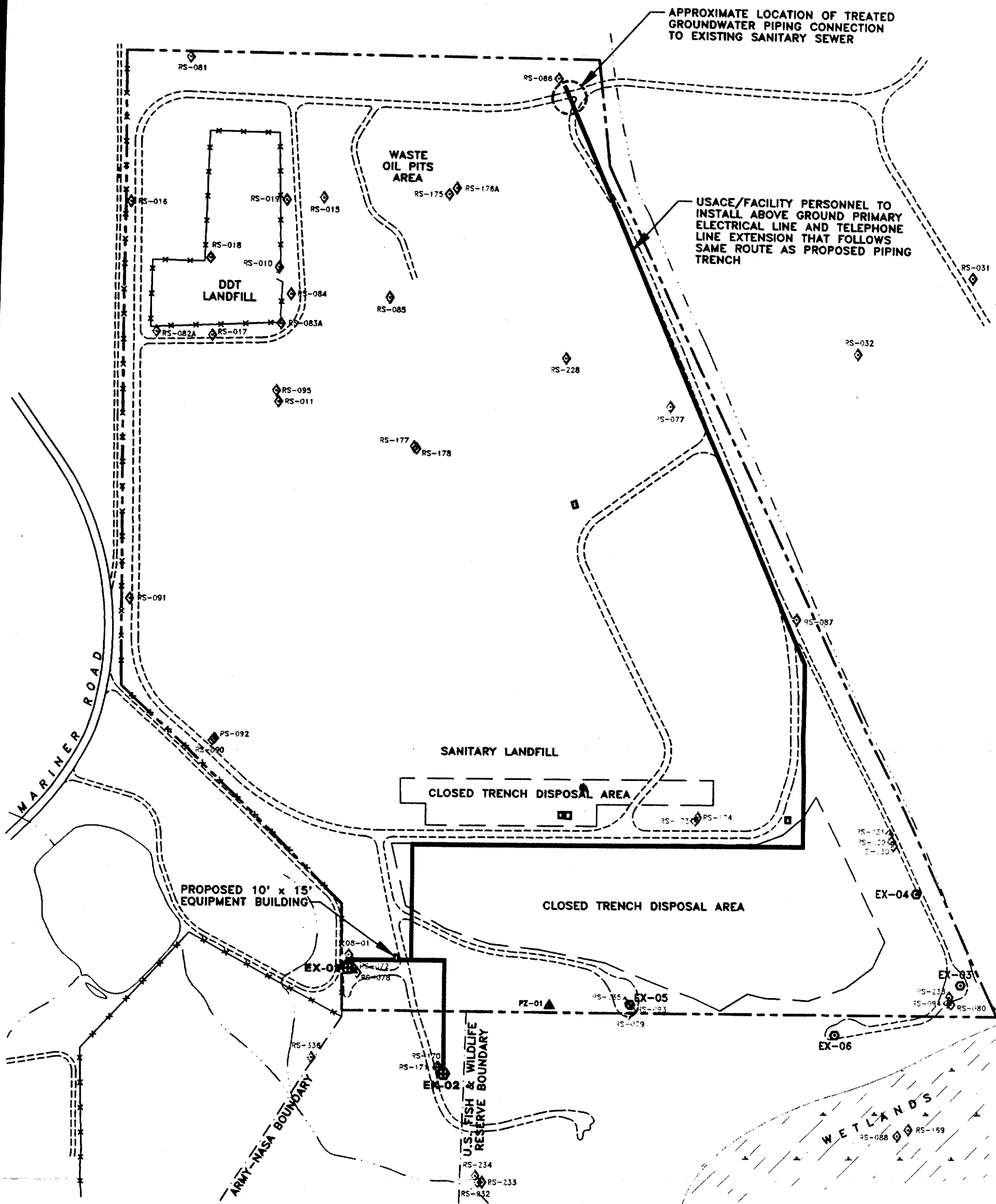
SHEET NO.	TITLE
1	PRELIMINARY EQUIPMENT COMPOUND AND TRENCHING LOCATION PLAN
2	PROCESS FLOW DIAGRAM
3	PIPING AND INSTRUMENTATION DIAGRAM - EXTRACTION AND TREATMENT SYSTEM
4	PIPING AND INSTRUMENTATION DIAGRAM LEGEND



U.S. ARMY ENGINEER DISTRICT  
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**APPENDIX A**  
**DRAWINGS**



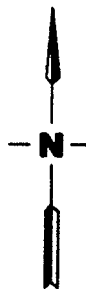
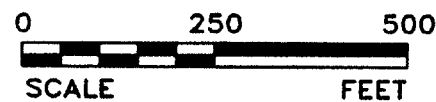
# **LEGEND:**

- APPROXIMATE BOUNDARY OF RSA-10
- FENCE
- SURFACE DRAINAGE
- PROPOSED PIPING TRENCH  
WIDTH = 2', DEPTH = 2'

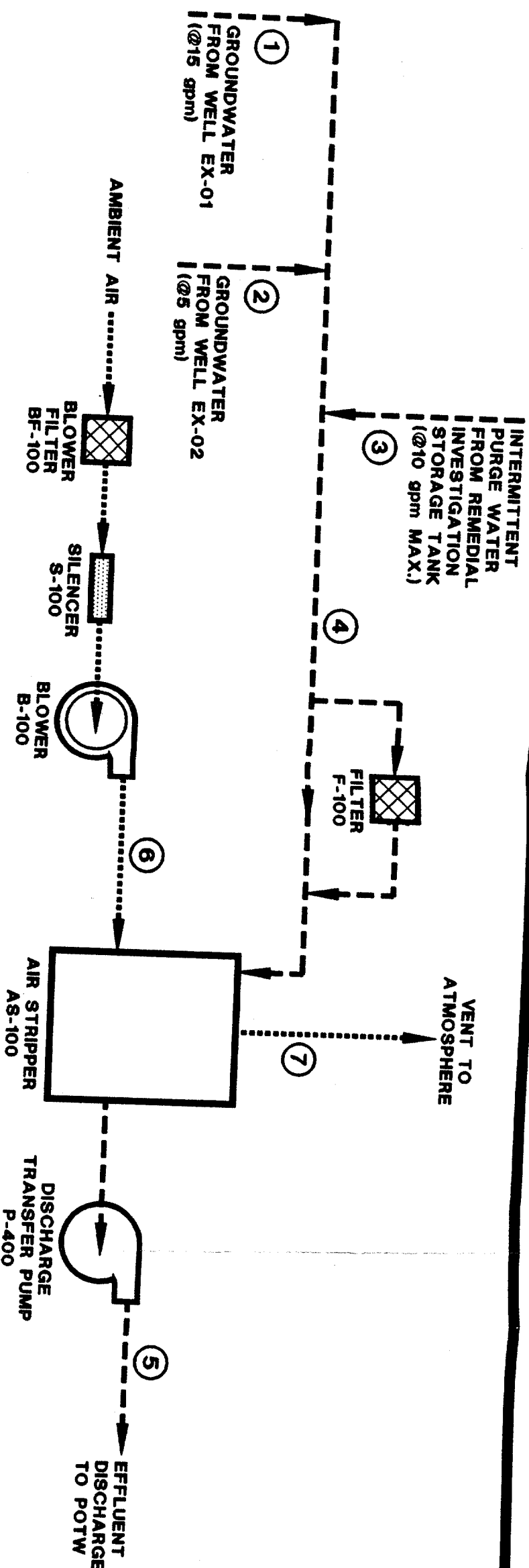
- ⊕ EXISTING INTERIM GROUNDWATER REMEDY GROUNDWATER EXTRACTION WELL
- ⊙ EXISTING GROUNDWATER EXTRACTION WELL
- ◇ EXISTING MONITORING WELL
- ▲ EXISTING PIEZOMETER

## **NOTE:**

OVERHEAD UTILITIES (ELECTRIC/PHONE) TO BE BROUGHT TO EQUIPMENT BUILDING AND TERMINATED BY USACE.



<b>ICF KAISER</b> 9300 LEE HIGHWAY FAIRFAX, VIRGINIA 22031-1207		JOB NO. 66942-001-00 DRAWING NO.	
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS SAVANNAH, GEORGIA			
RSA-10 INTERIM GROUNDWATER REMEDY <b>PRELIMINARY EQUIPMENT COMPOUND          AND TRENCHING LOCATION PLAN</b>			
REDSTONE ARSENAL		ALABAMA	
SIZE	INVITATION NO.	FILE NO.	PLATE
B			
SCALE: NO SCALE		SHEET: 1	



DESIGN BASIS/STREAM		1	2	3	4	5	6	7
MASS FLOW, lb/hr		7,506	2,502	5,004	15,012	25,020	1,584	1,368
VOLUME FLOW, gpm (AFCM)		15	5	10	30	50	(300)	(300)
TEMPERATURE, °F		55	55	55	55	60	50	60
PRESSURE, Psig (IWC)		78	78	TBD	5	125	(14)	(0)
SPECIFIC GRAVITY, DIMENSIONLESS (lb/ft³)		1.0	1.0	1.0	1.0	1.0	(0.088)	(0.076)
VISCOSITY, CP		1.0	1.0	1.0	1.0	1.0	0.018	0.018
pH		7.2-7.5	7.2-7.5	7.2-7.5	7.2-7.5	7.2-7.5	NA	NA
COMPOSITION								
WATER, wt%		>99	>99	>99	>99	>99	<0.5	<0.5
TRICHLOROETHENE, µg/L		2,500	2,500	2,500	2,500	3	0	0.037 lb/hr
1,1-DICHLOROETHENE		6	6	6	6	<1	0	4.5x10 <sup>-3</sup> lb/hr
TOLUENE		85	85	85	85	<1	0	6x10 <sup>-3</sup> lb/hr
SUSPENDED SOLIDS, ppm		<10	<10	<10	<10	<1	0	0
CARBONATE ALKALINITY, ppm		<350	<350	<350	<350	<350	NA	NA
MANGANESE, µg/L		~60	~60	~60	~60	~60	0	0
IRON, µg/L		~80	~80	~80	~80	~80	0	0
ZINC		~30	~30	~30	~30	~30	0	0
AIR, wt%		0	0	0	0	0	>99.5	>99.5

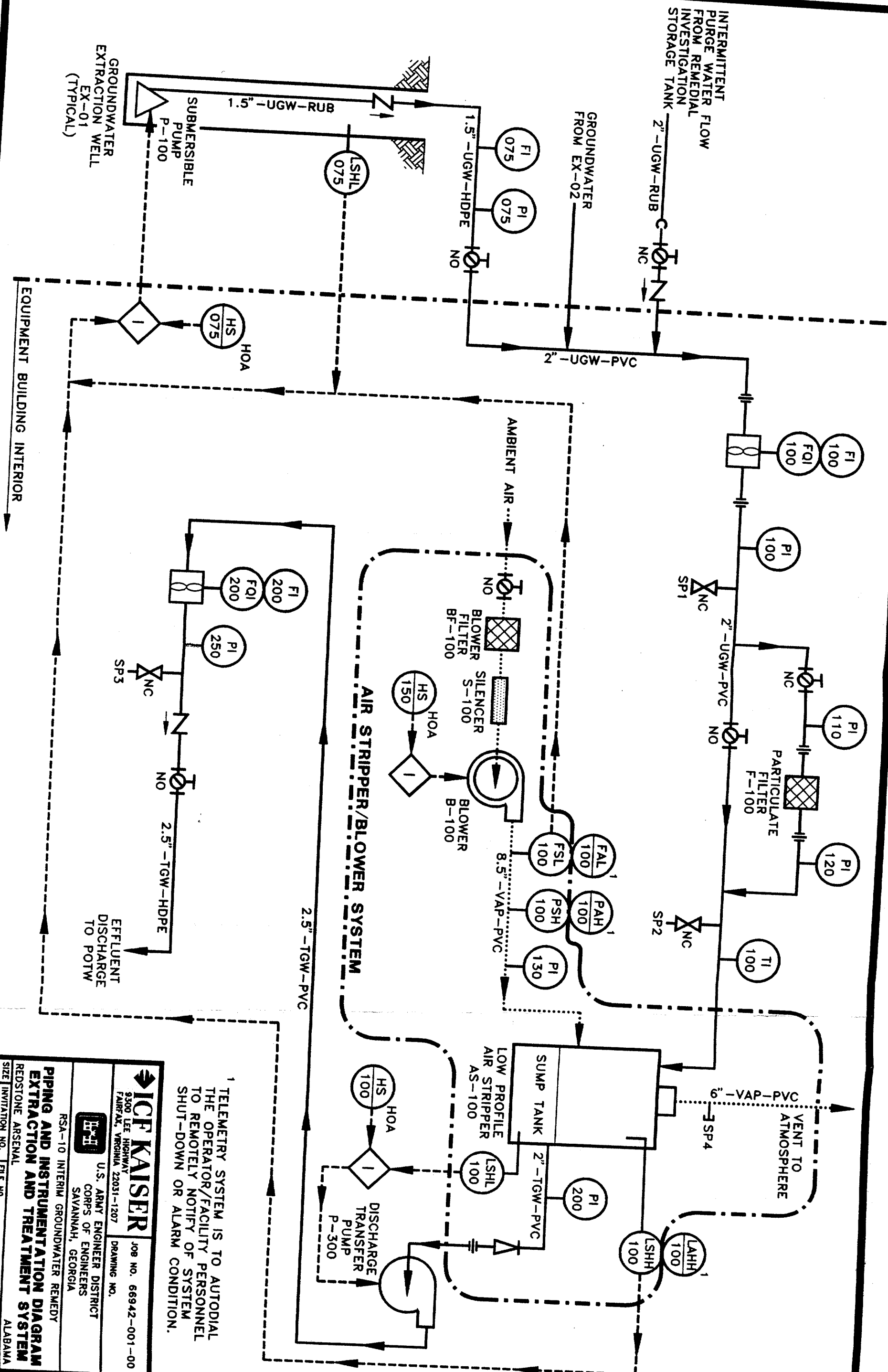
#### NOTES:

1. MAXIMUM DESIGN CAPACITY OF SYSTEM IS 30 GPM.
2. NOMINAL FLOWRATE IS EXPECTED TO BE 20 GPM.

#### LEGEND:

- WATER STREAM
- ..... VAPOR STREAM
- NA = NOT APPLICABLE
- NK = NOT KNOWN
- TBD = TO BE DETERMINED
- µg/L = MICROGRAMS PER LITER
- ppm = PARTS PER MILLION

<b>ICF KAISER</b> 8300 LEE HIGHWAY FAIRFAX, VIRGINIA 22031-1207		JOB NO. 66942-001-00 DRAWING NO.	
U.S. ARMY ENGINEER DISTRICT CORPS OF ENGINEERS SAVANNAH, GEORGIA		RSA-10 INTERIM GROUNDWATER REMEDY <b>PROCESS FLOW DIAGRAM</b>	
REDSTONE ARSENAL SIZE INVITATION NO.	FILE NO.	ALABAMA PLATE	SCALE: NO SCALE
SHEET: 2		REDSTONE\66942PFD.DWG 02/15/81	



TELEMETRY SYSTEM IS TO AUTODIAL THE OPERATOR/FACILITY PERSONNEL TO REMOTELY NOTIFY OF SYSTEM SHUT-DOWN OR ALARM CONDITION.

**ICF KAISER**  
9300 LEE HIGHWAY  
FAIRFAX, VIRGINIA 22031-1207

**U.S. ARMY ENGINEER DISTRICT**  
CORPS OF ENGINEERS  
SAVANNAH, GEORGIA

**ICF KAISER**  
CORP.

JOB NO. 66942-001-00  
DRAWING NO.

SAVANNAH, GEORGIA

**PIPING AND INSTRUMENTATION DIAGRAM**  
EXTRACTION AND TREATMENT SYSTEM  
REDSTONE ARSENAL

ALABAMA

SCALE: NO SCALE

SHEET: 3

# VALVE AND PIPING SYMBOLS

	GATE VALVE		BASKET TYPE STRAINER
	BUTTERFLY VALVE		Y-TYPE STRAINER
	CHECK VALVE		DUPLEX STRAINER
	PLUG VALVE		SLEEVE COUPLING (SC)
	3-WAY VALVE		FLOOR DRAIN
	ANGLE VALVE		EQUIPMENT DRAIN
	RELIEF OR SAFETY VALVE		CLEANOUT (CO)
	DIAPHRAGM VALVE		REMOVABLE PLUG
	BALL VALVE		REMOVABLE CAP
	SELF-CONTAINED PRESSURE REGULATING VALVE W/RELIEF		BLIND FLANGE
	BACK PRESSURE VALVE		EXHAUST TO ATMOSPHERE (INSIDE)
	KNIFE GATE VALVE		EXHAUST TO ATMOSPHERE (OUTSIDE)
	BACKFLOW PREVENTER		REDUCER
	NORMALLY OPEN		UNION
	NORMALLY CLOSED		QUICK DISCONNECT COUPLING
	FLEXIBLE HOSE		GAUGE SEAL
	ROTAMETER		

## VALVE OPERATOR SYMBOLS

	SOLENOID		DIAPHRAGM WITH POSITIONER
	MOTOR, ELECTRIC		HANDWHEEL OR LEVER
	DIAPHRAGM		CHAINWHEEL

## PRIMARY ELEMENT SYMBOLS - FLOW

	ORIFICE PLATE		FLUME
	PITOT TUBE		WEIR
	VENTURI OR FLOW TUBE		TURBINE OR TYPE METER
			PROPELLER TYPE METER
			MAGNETIC FLOW METER

## EQUIPMENT SYMBOLS

	SUBMERSIBLE PUMP		BLOWER
	AIR COMPRESSOR		PUMP
			PNEUMATIC DIAPHRAGM PUMP

## GENERAL INSTRUMENT SYMBOLS

ONE VARIABLE TWO VARIABLES

	LOCALLY MOUNTED
	PANEL MOUNTED
	REAR-OF-PANEL MOUNTED
	INTERLOCK
	PURGE

## LINE SYMBOLS

	AIR OR VAPOR PROCESS PIPES OR CHANNELS
	LIQUID PROCESS PIPES OR CHANNELS
	CONNECTION TO PROCESS MECHANICAL LINK OR INSTRUMENT SUPPLY
	PNEUMATIC SIGNAL
	ELECTRIC SIGNAL
	CAPILLARY TUBING (FILLED SYSTEM)
	HYDRAULIC SIGNAL
	ELECTROMAGNETIC OR SONIC SIGNAL
	NO WIRING OR TUBING

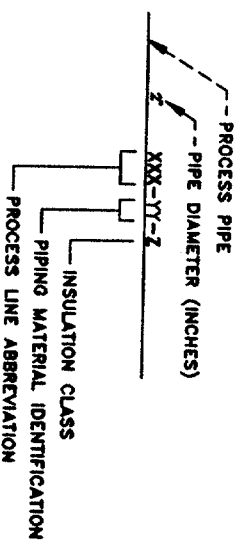
## PROCESS LINE ABBREVIATIONS

AR	AIR, ATMOSPHERIC PRESSURE
BW	BACKWASH
CA	COMPRESSED AIR
CAS	CASINO
D	DRAIN
DT	EFFLUENT
EX	EXHAUST
HP	HYDROGEN PEROXIDE
NPW	NON-POTABLE WATER
NUT	NUTRIENT
P	PRODUCT
PW	POTABLE WATER
S	SANITARY
SL	SAMPLE
SP	SLUDGE
ST	STORM SEWER
TF	TOTAL FLUIDS
UOW	UNTREATED GROUNDWATER
VAP	VAPOR

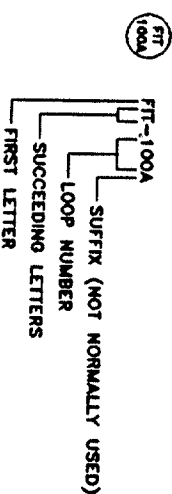
## PIPING MATERIAL IDENTIFICATION

AL	ALUMINUM
CPVC	CHLORINATED POLYVINYL CHLORIDE
CS	CARBON STEEL PIPE
CO	COPPER
CM	CORRUGATED METAL PIPE
CI	CAST IRON PIPE
DI	DUCTILE IRON PIPE
GS	GALVANIZED STEEL PIPE
PE	POLYETHYLENE PIPE
PP	POLYPROPYLENE PIPE
PVC	POLYVINYL CHLORIDE PIPE
RC	REINFORCED CONCRETE PIPE
RS	RUBBER HOSE
SS	STAINLESS STEEL PIPE
TUB	TUBING
VC	VITRIFIED CLAY PIPE

## PROCESS PIPING IDENTIFICATION



## INSTRUMENT IDENTIFICATION



## FUNCTION ABBREVIATIONS

DO	DISSOLVED OXYGEN	OC	OPEN-CLOSE
FE	FAIL CLOSED	OO	ON-OFF (MAINTAINED)
FI	FAIL INDETERMINATE	OR	OXIDATION REDUCTION
FL	FAIL LOCKED	OS	OPEN-STOP-CLOSE (MOMENTARY)
FO	FAIL OPEN	SS	START-STOP (MOMENTARY)
HOA	HAND-OFF-AUTOMATIC	>	HIGH SELECT
V/P	CURRENT-TO-PNEUMATIC	<	LOW SELECT
LEL	LOWER EXPLOSIVE LIMIT	Σ	SQUARE ROOT
LM	LOCAL-REMOTE	Δ	ADD OR TOTALIZE

**ICF KAISER**  
9300 LEE HIGHWAY  
FAIRFAX, VIRGINIA 22031-1207



U.S. ARMY ENGINEER DISTRICT  
CORPS OF ENGINEERS  
SAVANNAH, GEORGIA

RSA-10 INTERIM GROUNDWATER REMEDY  
**PIPING AND INSTRUMENTATION  
DIAGRAM LEGEND**

REDSTONE ARSENAL

ALABAMA

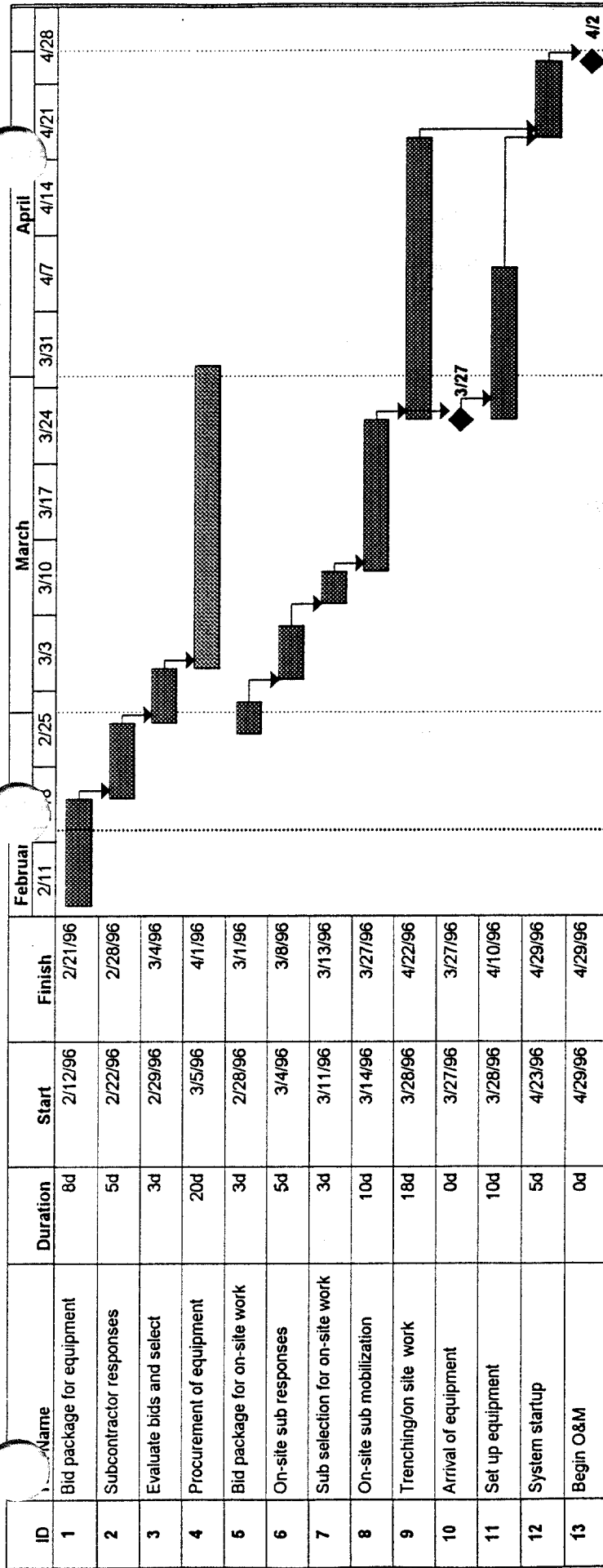
SIZE INVITATION NO. FILE NO.

B

PLATE

SCALE: NO SCALE

SHEET: 4



Project: RSA-10 Extended Pump Test  
Date: 2/19/96

Task

Progress

Milestone

Summary

Rolled Up Task

Rolled Up Milestone

Rolled Up Progress

Page 1

**APPENDIX B**  
**DESIGN CALCULATIONS**

## REDSTONE ARSENAL, ALABAMA INTERIM GROUNDWATER REMEDIATION SYSTEM

JOB NO. 66 942-001-00

Sheet 1 of 7

Designed By RT Date 2-15-96

Checked By NNA Date 2-15-96

### BURIEND TRENCHING HORIZONTAL LENGTHS

SCALE AS SHOWN

PUMP	DESIGN FLOW RATE (GPM)	HORIZONTAL TRENCH LENGTH (FT)	SELECTED PIPE DIAMETER (IN)	FRICTION LOSS
P-100	15	252'	1.5	1.71'/100'
P-200	5	360'	1	1.90'/100'
P-300	50	4195'	2.5	1.91'/100'

P-100 :  $20' + 232' = 252'$

P-200 :  $280' + 80' = 360'$

P-300 :  $280' + 942' + 458' + 1515' + 1000' = 4,195'$

DISCHARGE TRANSFER PUMP  
P-300

SUBMERSIBLE EXTRACTION  
WELL PUMP  
P-100

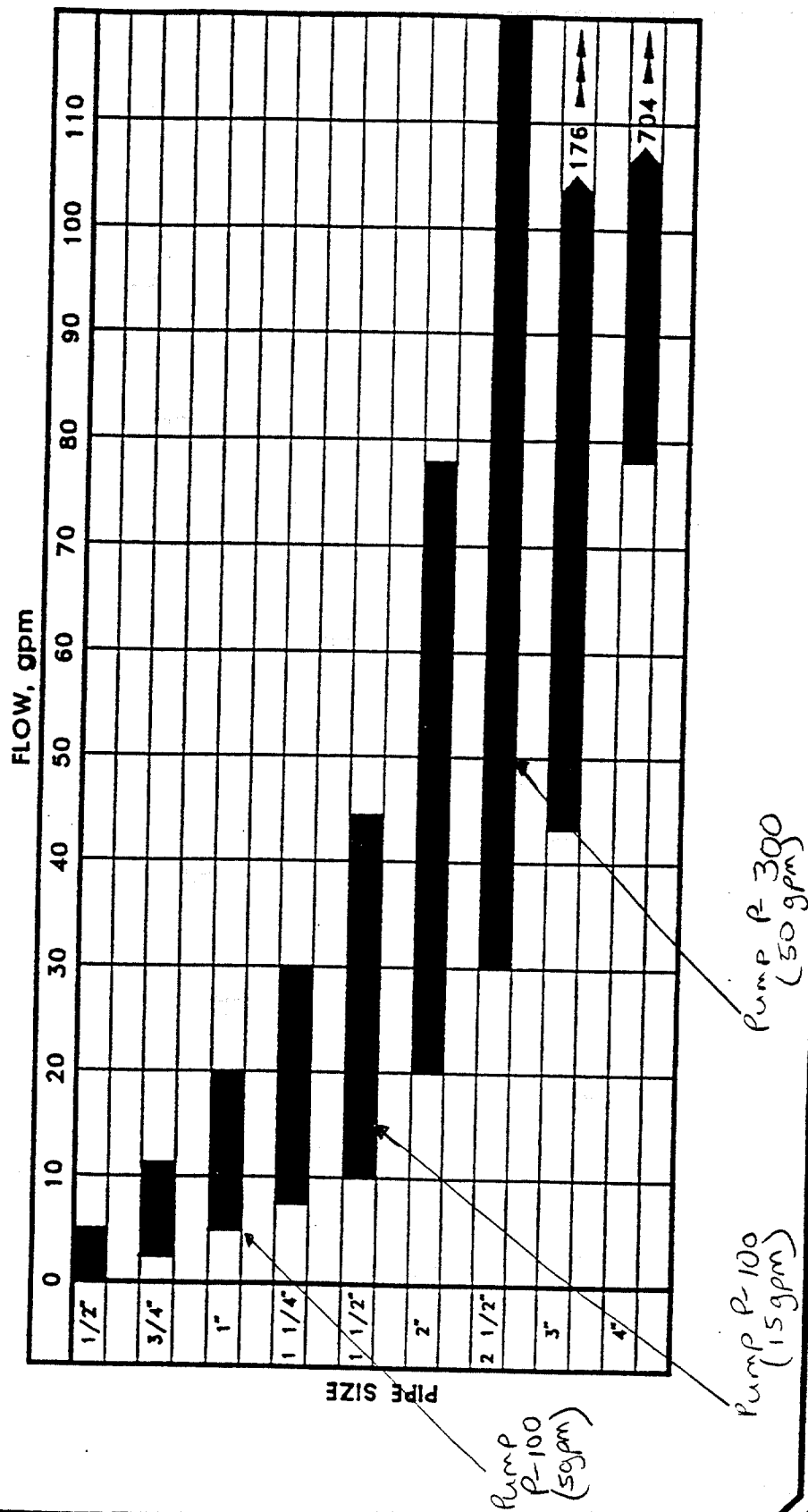
SUBMERSIBLE  
EXTRACTION WELL PUMP  
P-200

EX-01

EQUIPMENT  
SHED

EX-02

# **PIPE SIZE SELECTION** VELOCITY RANGE 2 - 8 fps



# ICF KAISER

JOB NO. 66942-001-00

TOTAL DYNAMIC HEAD (TDH)

Sheet 3 Of 7

SUBMERSIBLE EXTRACTION WELL PUMP

Designed By RT Date 2-15-96

REDSTONE ARSENAL, ALABAMA

Checked By NNA Date 2-15-96

INTERIM GROUNDWATER REMEDIATION SYSTEM

SUBMERSIBLE EXTRACTION WELL PUMP P-100

HDPE PIPE SIZE = 1.5"  $\rightarrow r = 0.75"$

TDH = GAIN IN POTENTIAL ENERGY + GAIN IN KINETIC ENERGY  
+ FRICTION LOSSES

$$= h_d - h_s + \frac{v^2}{2g} + h_f(s) + h_f(d)$$

$$= 150' - 0 + \left[ 15 \text{ gpm} \times \frac{\text{min}}{60 \text{ sec}} \times \frac{\text{ft}^3}{7.48 \text{ gal}} \times \frac{1}{\pi \left( \frac{0.75}{12} \right)^2 \text{ ft}^2} \right]^2 + h_f(d)$$

$$2(32.2) \text{ ft/s}^2$$

$$= 152.7 + h_f(d)$$

$h_d - h_s$  = TOP OF CASING ELEVATION DIFFERENCE =  $\sim 150'$  FROM SITE MAP

$h_f(d)$  = HEAD LOSS IN PIPING FITTINGS, VALVES, AND SPRAY NOZZLES

ASSUME 10% INCREASE IN TDH DUE TO FITTINGS,  
VALVES, AND NOZZLES

$h_f(d)$  CALCULATED USING: 1.5" PIPE HEAD LOSS @ 15 GPM  
OF  $\frac{1.71'}{100'}$

$$\text{HORIZONTAL LOSSES} = (20 + 232') \left( \frac{1.71'}{100'} \right)$$

$$= (252') \left( \frac{1.71'}{100'} \right)$$

$$= 4.3'$$

$$\text{TDH} = (152.7' + 4.3') \times 1.10$$

$$= 172.7'$$

10% increase in TDH due to fittings,  
valves, and nozzles

DESIGN CAPACITY: 15 gpm @ 180' TDH

GRUNDFOS MODEL 16E SERIES IS SPECIFIED

# ICF KAISER

JOB NO. 66942-001-00

TOTAL DYNAMIC HEAD (TDH)

Sheet 4 Of 7

SUBMERSIBLE EXTRACTION WELL AND

Designed By RT Date 2-15-96

REDSTONE ARSENAL, ALABAMA

Checked By VNA Date 2-15-96

INTERIM GROUNDWATER REMEDIATION SYSTEM

SUBMERSIBLE EXTRACTION WELL PUMP P-200

HDPE PIPE SIZE = 1"  $\Rightarrow r = 0.5"$

TDH = GAIN IN POTENTIAL ENERGY + GAIN IN KINETIC ENERGY  
+ FRICTION LOSSES

$$= h_d - h_s + \frac{v^2}{2g} + h_{fs} + h_f(d)$$

$$= 150' - 0 + \left[ 5 \text{ gpm} \times \frac{\text{min}}{60 \text{ sec}} \times \frac{f+3}{7.48 \text{ gal}} \times \frac{1}{\pi (0.5)^2 f+2} \right]^2 + h_f(d)$$

$$= 151.8 + h_f(d)$$

$h_d - h_s$  = TOP OF CASING ELEVATION DIFFERENCE = ~150' FROM SITE MAP

$h_f(d)$  = HEAD LOSS IN PIPING FITTINGS, VALVES, AND NOZZLES

ASSUME 10% INCREASE IN TDH DUE TO FITTINGS, VALVES, AND NOZZLES

$h_f(d)$  CALCULATED USING 1" PIPE HEAD LOSS @  
5 gpm of  $\frac{1.90'}{100'}$

$$\text{HORIZONTAL LOSSES} = (280' + 80') \left( \frac{1.90'}{100'} \right)$$

$$= (360') \left( \frac{1.90'}{100'} \right)$$

$$= 6.8'$$

$$\text{TDH} = (151.8 + 6.8') (1.10)$$

$$= 174.5'$$

DESIGN CAPACITY: 5 gpm @ 180' TDH

GRUNDOS MODEL 5E SERIES IS SPECIFIED

# ICF KAISER

JOB NO. 66942-001-00

TOTAL DYNAMIC HEAD (TDH)

Sheet 5 Of 7

DISCHARGE PUMP

Designed By RT Date 2-15-96

Redstone Arsenal Alabama

Checked By NNA Date 2-15-96

Interim Groundwater Remediation System

Discharge Transfer Pump P-300

HDPE Pipe Size - 2.5"  $\Rightarrow r = 1.25"$

TDH = GAIN IN POTENTIAL ENERGY + GAIN IN KINETIC ENERGY  
+ FRICTION LOSSES

$$= h_d - h_s + \frac{v^2}{2g} + h_{f(s)} + h_{f(d)}$$

$$= 35' - 0 + \left[ \frac{50 \text{ gpm} \times \frac{\text{min}}{60 \text{ s}} \times \frac{\text{ft}^3}{7.48 \text{ gal}} \times \frac{1}{\pi \left( \frac{1.25}{2} \right)^2 \text{ ft}^2}} \right]^2 \times \frac{2 (32.2) \text{ ft/s}^2}{} + h_{f(d)}$$

$$= 38.3' + h_{f(d)}$$

$$h_d - h_s = \text{TOPO Elevation Difference} = \sim 35' \text{ from site map}$$

$h_{f(d)}$  = HEAD LOSS IN PIPING, FITTINGS, VALVES + HORIZONTAL LOSSES  
(using 2.5" pipe head loss @ 50 gpm is 1.56'/100' pipe)

$$\text{HORIZONTAL LOSSES} = (1515' + 458' + 942' + 280' + 1000') \left( \frac{1.56'}{100'} \right) = (4,195') \left( \frac{1.91}{100'} \right) = 80.1'$$

Assume 10% HEAD INCREASE DUE TO FITTINGS, VALVES, AND NOZZLES

$$\text{TDH} = (38.3' + 80.1') (1.10) = 130.1'$$

Design Capacity: 50 gpm @ 144' TDH

Price Pump Co. Model A-100 Series is specified.

Friction of Water New Steel Pipe (Continued)  
(Based on Darcy's Formula)

1 Inch

Flow U S gal per min	Standard wt steel—sch 40				Extra strong steel—sch 80				Schedule 160 steel			
	1.049" inside dia				.957" inside dia				.815" inside dia			
	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft
2	0.74	.009	.385	.01	.599	.123	.023	.126	.123	.023	.126	.126
3	1.11	.019	.787	.03	.119	.185	.053	2.60	.185	.053	2.60	2.60
4	1.48	.034	1.270	.05	.199	.246	.094	4.40	.246	.094	4.40	4.40
5	1.86	.054	1.90	.08	.299	.308	.147	6.63	.308	.147	6.63	6.63
6	2.23	.077	2.65	.11	.417	.369	.211	9.30	.369	.211	9.30	9.30
8	2.97	.137	4.50	.20	.711	.492	.376	15.9	.492	.376	15.9	15.9
10	3.71	.214	6.81	.31	1.08	.615	.587	24.3	.615	.587	24.3	24.3
12	4.45	.308	9.58	.45	15.2	.738	.845	34.4	.738	.845	34.4	34.4
14	5.20	.420	12.8	.61	20.4	.861	1.15	46.2	.861	1.15	46.2	46.2
16	5.94	.548	16.5	.79	26.3	.984	1.50	59.7	.984	1.50	59.7	59.7
18	6.68	.694	20.6	1.00	32.9	1.107	1.90	74.9	1.107	1.90	74.9	74.9
20	7.42	.857	25.2	1.24	40.3	1.230	2.35	91.8	1.230	2.35	91.8	91.8
22	8.17	1.036	30.3	1.50	48.4	1.373	2.84	110	1.373	2.84	110	110
24	8.91	1.23	35.8	1.8	57.2	1.476	3.38	131	1.476	3.38	131	131
26	9.65	1.45	41.7	2.1	66.8	1.599	3.97	153	1.599	3.97	153	153
28	10.39	1.68	48.1	2.4	77.1							
30	11.1	1.93	55.0	2.8	88.2							
32	11.8	2.19	62.2	3.2	100							
34	12.5	2.46	70.0	3.6	113							
36	13.2	2.74	78.3	4.0	127							
38	13.9	3.03	87.1	4.4	142							
40	14.6	3.33	96.1	4.8	158							
42	15.3	3.64	106	5.2	175							
44	16.0	3.96	116	5.6	194							
46	16.7	4.29	127	6.0								
48	17.4	4.63	138	6.4								
50	18.1	4.98	150	6.8								
52	18.8	5.34	162	7.2								
54	19.5	5.71	175	7.6								
56	20.2	6.08	188	8.0								
58	20.9	6.46	201	8.4								
60	21.6	6.84	215	8.8								
62	22.3	7.23	229	9.2								
64	23.0	7.62	244	9.6								
66	23.7	8.02	259	10.0								
68	24.4	8.42	274	10.4								
70	25.1	8.83	290	10.8								
72	25.8	9.24	305	11.2								
74	26.5	9.65	321	11.6								
76	27.2	10.07	337	12.0								
78	27.9	10.49	353	12.4								
80	28.6	10.92	370	12.8								
82	29.3	11.35	386	13.2								
84	30.0	11.78	403	13.6								
86	30.7	12.22	420	14.0								
88	31.4	12.66	437	14.4								
90	32.1	13.11	455	14.8								
92	32.8	13.56	472	15.2								
94	33.5	14.01	490	15.6								
96	34.2	14.47	508	16.0								
98	34.9	14.93	526	16.4								
100	35.6	15.39	545	16.8								

Note: No allowance has been made for age, difference in diameter, or any abnormal condition of interior surface. Any factor of safety must be estimated from the local conditions and the requirements of each particular installation. It is recommended that for most commercial design purposes a safety factor of 15 to 20% be added to the values in the tables—see page 3-5.

Friction of Water New Steel Pipe (Continued)  
(Based on Darcy's Formula)

1 1/2 Inch

Flow U S gal per min	Standard wt steel—sch 40				Extra strong steel—sch 80				Schedule 160—steel			
	1.610" inside dia				1.500" inside dia				1.338" inside dia			
	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft
4	.63	.006	.166	.01	.73	.233	.913	.404	.913	.205	.085	1.67
5	.79	.010	.246	.01	.91	.346	1.14	.601	1.14	.323	.081	2.03
6	1.09	.014	.340	.02	1.17	.478	1.37	.832	1.37	.456	.116	2.84
7	1.10	.019	.447	.03	1.27	.630	1.60	1.10	1.60	.602	.158	3.78
8	1.26	.025	.567	.03	1.45	.800	1.83	1.35	1.83	.802	.207	4.85
9	1.42	.031	.701	.04	1.63	.990	2.05	1.67	2.05	.985	.282	6.04
10	1.58	.039	.848	.05	1.82	1.20	2.28	2.03	2.28	1.16	.391	7.36
12	1.89	.058	1.18	.07	2.18	1.61	2.74	2.84	2.74	1.58	.502	9.81
14	2.21	.076	1.51	.10	2.54	2.14	3.20	3.78	3.20	2.07	.685	12.1
16	2.52	.099	1.93	.13	2.90	2.74	3.65	4.85	3.65	2.52	.880	15.9
18	2.84	.125	2.40	.17	3.27	3.41	4.11	6.04	4.11	3.23	.934	20.2
20	3.15	.154	2.92	.20	3.63	4.15	4.56	7.36	4.56	3.91	1.05	22.5
22	3.47	.187	3.48	.25	3.99	4.96	5.02	8.81	5.02	4.36	1.17	25.0
24	3.78	.222	4.10	.30	4.36	5.84	5.48	10.4	5.48	4.85	1.29	27.6
26	4.10	.261	4.76	.35	4.72	6.80	5.93	12.1	5.93	5.34	1.43	30.3
28	4.41	.303	5.47	.40	5.08	7.82	6.39	13.9	6.39	5.85	1.57	33.1
30	4.73	.347	6.23	.46	5.45	8.91	6.85	15.9	6.85	6.34	1.71	36.1
32	5.04	.395	7.04	.52	5.81	10.1	7.30	18.0	7.30	6.82	1.86	39.2
34	5.36	.446	7.90	.59	6.17	11.3	7.76	20.2	7.76	7.34	2.02	42.4
36	5.67	.500	8.80	.66	6.54	12.6	8.22	22.5	8.22	7.93	2.17	45.0
38	5.99	.557	9.76	.74	6.90	14.0	8.67	25.0	8.67	8.58	2.32	47.6
40	6.30	.618	10.8	.82	7.26	15.4	9.13	27.6	9.13	9.08	2.47	50.2
42	6.62	.681	11.8	.90	7.63	16.9	9.58	30.3	9.58	9.58	2.62	52.8
44	6.93	.747	12.9	.99	7.99	18.5	10.04	33.1	10.04	10.04	2.77	55.4
46	7.25	.817	14.0	1.08	8.35	20.1	10.50	36.1	10.50	10.50	2.92	58.0
48	7.56	.889	15.2	1.18	8.72	21.8	10.95	39.2	10.95	10.95	3.07	60.6
50	7.86	.965	16.5	1.28	9.08	23.6	11.41	42.4	11.41	11.41	3.22	63.2
52	8.17	1.04	17.8	1.38	9.45	25.4	11.87	45.0	11.87	11.87	3.37	65.8
54	8.47	1.12	19.1	1.48	9.81	27.2	12.33	47.6	12.33	12.33	3.52	68.4
56	8.78	1.20	20.4	1.58	10.17	29.0	12.79	50.2	12.79	12.79	3.67	71.0
58	9.08	1.28	21.7	1.68	10.53	30.8	13.25	52.8	13.25	13.25	3.82	73.6
60	9.38	1.36	23.0	1.78	10.89	32.6	13.71	55.4	13.71	13.71	3.97	76.2
62	9.68	1.44	24.3	1.88	11.25	34.4	14.17	58.0	14.17	14.17	4.12	78.8
64	9.98	1.52	25.6	1.98	11.61	36.2	14.63	60.6	14.63	14.63	4.27	81.4
66	10.28	1.60	26.9	2.08	11.97	38.0	15.09	63.2	15.09	15.09	4.42	84.0
68	10.58	1.68	28.2	2.18	12.33	39.8	15.55	65.8	15.55	15.55	4.57	86.6
70	10.88	1.76	29.5	2.28	12.69	41.6	16.01	68.4	16.01	16.01	4.72	89.2
72	11.18	1.84	30.8	2.38	13.05	43.4	16.47	71.0	16.47	16.47	4.87	91.8
74	11.48	1.92	32.1	2.48	13.41	45.2	16.93	73.6	16.93	16.93	5.02	94.4
76	11.78	2.00	33.4	2.58	13.77	47.0	17.39	76.2	17.39	17.39	5.17	97.0
78	12.08	2.08	34.7	2.68	14.13	48.8	17.85	78.8	17.85	17.85	5.32	99.6
80	12.38	2.16	36.0	2.78	14.49	50.6	18.31	81.4	18.31	18.31	5.47	102.2
82	12.68	2.24	37.3	2.88	14.85	52.4	18.77	84.0	18.77	18.77	5.62	104.8
84	12.98	2.32	38.6	2.98	15.21	54.2	19.23	86.6	19.23	19.23	5.77	107.4
86	13.28	2.40	39.9	3.08	15.57	56.0	19.69	89.2	19.69	19.69	5.92	110.0
88	13.58	2.48	41.2	3.18	15.93	57.8	20.15	91.8	20.15	20.15	6.07	112.6
90	13.88	2.56	42.5	3.28	16.29	59.6	20.61	94.4	20.61	20.61	6.22	115.2
92	14.18	2.64	43.8	3.38	16.65	61.4	21.07	97.0	21.07	21.07	6.37	117.8
94	14.48	2.72	45.1	3.48	17.01	63.2	21.53	100.0	21.53	21.53	6.52	120.4
96	14.78	2.80	46.4	3.58	17.37	65.0	21.99	103.0	21.99	21.99	6.67	123.0
98	15.08	2.88	47.7	3.68	17.73	66.8	22.45	105.6	22.45	22.45	6.82	125.

Friction of Water New Steel Pipe (Continued)  
(Based on Darcy's Formula)  
2 Inch

Flow U S gal per min	Standard wt steel—sch 40				Extra strong steel—sch 80				Schedule 160—steel			
	2.067" inside dia				1.939" inside dia				1.687" inside dia			
	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft
5	.478	.004	.004	.074	.54	.101	.000	.197	.008	.718	.008	.197
6	.574	.005	.005	.102	.65	.139	.01	.271	.012	.861	.012	.271
7	.669	.007	.007	.134	.76	.182	.01	.357	.016	.101	.016	.357
8	.765	.009	.009	.170	.87	.231	.01	.452	.020	.115	.020	.452
9	.860	.012	.012	.208	.98	.285	.01	.559	.026	.129	.026	.559
10	.956	.014	.014	.252	1.09	.343	.02	.675	.032	.144	.032	.675
12	1.15	.021	.021	.349	1.30	.476	.03	.938	.046	.172	.046	.938
14	1.34	.028	.028	.461	1.52	.629	.04	1.250	.063	.201	.063	1.250
16	1.53	.036	.036	.586	1.74	.800	.05	1.530	.082	.230	.082	1.530
18	1.72	.046	.046	.725	1.96	.991	.06	1.900	.104	.258	.104	1.900
20	1.91	.057	.057	.876	2.17	1.16	.07	2.310	.128	.287	.128	2.310
22	2.10	.069	.069	1.05	2.39	1.38	.09	2.760	.155	.316	.155	2.760
24	2.29	.082	.082	1.18	2.61	1.62	.11	3.250	.184	.345	.184	3.250
26	2.49	.096	.096	1.37	2.83	1.88	.12	3.770	.216	.373	.216	3.770
28	2.68	.111	.111	1.57	3.04	2.16	.14	4.330	.251	.402	.251	4.330
30	2.87	.128	.128	1.82	3.26	2.46	.17	4.930	.288	.431	.288	4.930
35	3.35	.174	.174	2.38	3.80	3.28	.22	6.390	.392	.502	.392	6.390
40	3.82	.227	.227	3.06	4.35	4.21	.29	8.490	.512	.574	.512	8.490
45	4.30	.288	.288	3.82	4.89	5.26	.37	10.600	.648	.618	.648	10.600
50	4.78	.355	.355	4.66	5.43	6.42	.46	13.000	.799	.718	.799	13.000
55	5.26	.430	.430	5.58	5.98	7.70	.56	15.600	.967	.789	.967	15.600
60	5.74	.511	.511	6.58	6.52	8.99	.66	18.400	1.15	.861	1.15	18.400
65	6.21	.600	.600	7.65	7.06	10.59	.77	21.500	1.35	.933	1.35	21.500
70	6.69	.696	.696	8.82	7.61	12.2	.90	24.800	1.57	1.005	1.57	24.800
75	7.17	.799	.799	10.1	8.15	13.9	1.03	28.300	1.80	1.077	1.80	28.300
80	7.65	.909	.909	11.4	8.69	15.8	1.17	32.100	2.05	1.148	2.05	32.100
85	8.13	1.03	1.03	12.8	9.03	17.7	1.27	36.100	2.31	1.220	2.31	36.100
90	8.60	1.15	1.15	14.3	9.78	19.8	1.49	40.300	2.59	1.292	2.59	40.300
95	9.08	1.28	1.28	15.9	10.3	22.0	1.6	44.800	2.89	1.364	2.89	44.800
100	9.56	1.42	1.42	17.5	10.9	24.3	1.8	49.500	3.20	1.435	3.20	49.500
110	10.52	1.72	1.72	21.0	12.0	29.2	2.2	58.600	3.87	1.579	3.87	58.600
120	11.5	2.05	2.05	24.9	13.0	34.5	2.6	68.800	4.61	1.722	4.61	68.800
130	12.4	2.40	2.40	29.1	14.1	40.3	3.1	82.600	5.40	1.866	5.40	82.600
140	13.4	2.78	2.78	33.6	15.2	46.6	3.6	95.500	6.27	2.010	6.27	95.500
150	14.3	3.20	3.20	38.4	16.3	53.3	4.1	109	7.20	2.153	7.20	109
160	15.3	3.64	3.64	43.5	17.4	60.5	4.7	124	8.19	2.297	8.19	124
170	16.3	4.11	4.11	49.0	18.5	68.1	5.3	140	9.24	2.440	9.24	140
180	17.2	4.60	4.60	54.8	19.6	76.1	6.0	156	10.36	2.584	10.36	156
190	18.2	5.13	5.13	60.9	20.6	84.6	6.6	174	11.54	2.727	11.54	174
200	19.1	5.68	5.68	67.3	21.7	93.6	7.3	192	12.79	2.871	12.79	192
220	21.0	6.88	6.88	81.1	23.9	113	8.9	228	15.13	3.165	15.13	228
240	22.9	8.18	8.18	96.2	26.9	134	10.6	268	17.62	3.460	17.62	268
260	24.9	9.60	9.60	113	29.3	157	12.4	312	20.16	3.755	20.16	312
280	26.8	11.14	11.14	130	32.6	181	14.4	360	22.75	4.050	22.75	360
300	28.7	12.8	12.8	149	36.6	208	16.5	412	25.39	4.345	25.39	412

Note: No allowance has been made for age, difference in diameter, or any abnormal condition of interior surface. Any factor of safety must be estimated from the local conditions and the requirements of each particular installation. It is recommended that for most commercial design purposes a safety factor of 15 to 20% be added to the values in the tables—see page 3-5.

Friction of Water New Steel Pipe (Continued)  
(Based on Darcy's Formula)  
2 1/2 Inch

Flow U S gal per min	Standard wt steel—sch 40				Extra strong steel—sch 80				Schedule 160—steel			
	2.469" inside dia				2.323" inside dia				2.125" inside dia			
	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft	Velocity ft per sec	Head loss ft per 100 ft
8	.536	.005	.005	.072	.61	.01	.008	.149	.724	.008	.724	.149
10	.670	.007	.007	.107	.76	.01	.108	.221	.905	.013	.905	.221
12	.804	.009	.009	.148	.91	.01	.139	.305	1.09	.018	1.09	.305
14	.938	.014	.014	.195	1.06	.02	.161	.403	1.27	.025	1.27	.403
16	1.07	.018	.018	.247	1.21	.02	.188	.512	1.45	.033	1.45	.512
18	1.21	.023	.023	.305	1.36	.03	.215	.634	1.63	.041	1.63	.634
20	1.34	.028	.028	.368	1.51	.04	.242	.767	1.81	.051	1.81	.767
22	1.47	.034	.034	.438	1.67	.04	.270	.912	1.99	.061	1.99	.912
24	1.61	.040	.040	.513	1.82	.05	.300	1.03	2.17	.073	2.17	1.03
26	1.74	.047	.047	.593	1.97	.06	.332	1.20	2.35	.086	2.35	1.20
28	1.88	.055	.055	.678	2.12	.07	.365	1.37	2.53	.100	2.53	1.37
30	2.01	.063	.063	.770	2.27	.08	.400	1.56	2.71	.114	2.71	1.56
35	2.35	.086	.086	.999	2.65	.11	.478	2.08	3.17	.156	3.17	2.08
40	2.68	.112	.112	1.26	3.03	.14	.572	2.66	3.62	.203	3.62	2.66
45	3.02	.141	.141	1.57	3.41	.18	.686	3.32	4.07	.257	4.07	3.32
50	3.35	.174	.174	1.91	3.79	.22	.811	4.05	4.52	.318	4.52	4.05
55	3.69	.211	.211	2.28	4.16	.27	.946	4.85	4.98	.384	4.98	4.85
60	4.02	.251	.251	2.69	4.54	.32	1.090	5.72	5.43	.457	5.43	5.72
65	4.36	.295	.295	3.13	4.92	.38	1.244	6.66	5.88	.537	5.88	6.66
70	4.69	.342	.342	3.60	5.30	.44	1.400	7.67	6.33	.622	6.33	7.67
75	5.03	.393	.393	4.10	5.68	.50	1.558	8.75	6.79	.714	6.79	8.75
80	5.36	.447	.447	4.64	6.05	.57	1.714	9.90	7.24	.813	7.24	9.90
85	5.70	.504	.504	5.20	6.43	.64	1.878	11.1	7.69	.918	7.69	11.1
90	6.03	.565	.565	5.80	6.81	.72	2.044	12.4	8.14	1.03	8.14	12.4
95	6.37	.630	.630	6.43	7.19	.80	2.212	13.8	8.59	1.15	8.59	13.8
100	6.70	.698	.698	7.09	7.57	.89	2.382	15.2	9.05	1.27	9.05	15.2
110	7.37	.844	.844	8.51	8.33	1.08	2.700	18.3	9.95	1.54	9.95	18.3
120	8.04	1.00	1.00	10.1	9.08	1.28	3.028	21.6	10.86	1.83	10.86	21.6
130	8.71	1.18	1.18	11.7	9.84	1.50	3.366	25.2	11.76	2.15	11.76	25.2
140	9.38	1.37	1.37	13.5	10.6	1.7	3.714	29.1	12.67	2.49	12.67	29.1
150	10.05	1.57	1.57	15.5	11.3	2.0	4.072	33.3	13.57	2.86	13.57	33.3
160	10.7	1.79	1.79	17.5	12.1	2.3	4.440	37.8	14.47	3.25	14.47	37.8
170	11.4	2.02	2.02	19.7	12.9	2.6	4.818	42.5	15.37	3.67	15.37	42.5
180	12.1	2.26	2.26	22.0	13.6	2.9	5.200	47.9	16.28	4.12	16.28	47.9
190	12.7	2.52	2.52	24.4	14.4	3.2	5.588	52.8	17.19	4.59	17.19	52.8
200	13.4	2.79	2.79	27.0	15.1	3.5	5.980	58.4	18.09	5.08	18.09	58.4
220	14.7	3.38	3.38	32.5	16.7	4.3	6.712	70.3	19.90	6.15	19.90	70.3
240	16.1	4.02	4.02	38.5	18.2	5.1	7.444	83.4	21.71	7.32	21.71	83.4
260	17.4	4.72	4.72	45.0	19.7	6.0	8.176	97.6	23.52	8.59	23.52	97.6
280	18.8	5.47	5.47	52.3	21.2	7.0	8.908	113	25.33	9.96	25.33	113
300	20.1	6.28	6.28	59.6	22.7	8.0	9.640	129	27.14	11.43	27.14	129
350	23.5	8.55	8.55	80.6	26.5	10.9	11.600	175	31.68	15.56	31.68	175
400	26.8	11.2	11.2	105	30.3	14.3	14.400	228	36.19	20.32	36.19	228
450	30.2	14.1	14.1	132	34.1	18.1	17.200	288	40.71	25.72	40.71	288
500	33.5	17.4	17.4	163	37.9	22.3	20.000	354	45.23	31.75	45.23	354

Note: No allowance has been made for age, difference in diameter, or any abnormal condition of interior surface. Any factor of safety must be estimated from the local conditions and the requirements of each particular installation. It is recommended that for most commercial design purposes a safety factor of 15 to 20% be added to the values in the tables—see page 3-5.

**ENGINEERS**

Job No. 60772-001-00

SHEET 1 OF 2

Groundwater Extraction + Treatment System

- Red Stone Arsenal, Alabama

Air Emissions

DESIGNED BY NNA

DATE 2/15/96

CHECKED BY

DATE

TCE Mass Flowrate in the off-gas?

$$m_{TCE} = Q_w C_{TCE,i} E$$

where  $Q_w$  = system flowrate (gpm) = 30 gpm

$C_{TCE,i}$  = influent TCE concentration in groundwater (mg/L)  
= 2,500 mg/L

$E$  = removal efficiency

$m_{TCE}$  = Mass flowrate of TCE in off-gas

$$m_{TCE} = 30 \frac{\text{gal}}{\text{min}} \times 2,500 \frac{\text{mg}}{\text{L}} \times 3.785 \frac{\text{L}}{\text{gal}} \times \frac{1 \text{ g}}{1 \times 10^6 \text{ mg}} \times \frac{1 \text{ lb}}{453.6 \text{ g}} \times E$$

$$= 30 \frac{\text{gal}}{\text{min}} \times 2,500 \frac{\text{mg}}{\text{L}} \times 3.785 \frac{\text{L}}{\text{gal}} \times 2.21 \times 10^{-9} \frac{\text{lb}}{\text{mg}} \times E$$

Based on North East Environmental modeling,  
expected removal<sup>TCE</sup> efficiency for Model 2331-P  
low profile air stripper  $E = 99.9096\%$   
for 2,500 mg/L influent TCE concentration

$$m_{TCE} = 30 \times 2500 \times 3.785 \times 2.21 \times 10^{-9} \times 0.999096$$

$$= 0.00063 \text{ lb/min} \times 60 \frac{\text{min}}{\text{hr}}$$

$$m_{TCE} = 0.0375 \text{ lb/hr}$$

**ENGINEERS**JOB NO. W-12-W-00

SHEET 2 OF 2

Groundwater Extraction + Treatment Sys.

Red Stone Arsenal

Air Emissions

DESIGNED BY N/ADATE 2/15/96

CHECKED BY

DATE

TCE Concentration in off-gas?

$$C_{TCE,air} = \frac{m_{TCE}}{A.F. Flow}$$

$$m_{TCE} = 0.0375 \text{ lb/hr}$$

$$C_{TCE,air} = \frac{0.0375 \text{ lb/hr} \times \frac{1 \text{ mg}}{2.21 \times 10^{-9} \text{ lb}}}{300 \text{ ft}^3/\text{min} \times \frac{7.48 \text{ gal}}{\text{ft}^3} \times \frac{3.785 \text{ L}}{\text{gal}} \times 60 \text{ min/hr}}$$

$$= 33.3 \text{ mg/L} = 33.3 \text{ ppbv}$$

$$C_{TCE,air} = 0.0333 \text{ ppmv}$$

@ 300 CFM, 60°F

CALCULATION  
Form No. E-6 Rev. 12-89

**ENGINEERS**JOB NO. 703 934 3315

SHEET 1 OF 3

Groundwater Extraction + Treatment System

Redstone Arsenal, Alabama

Air Stripper Sizing

DESIGNED BY NNADATE 2/15/96

CHECKED BY

DATE

Design Basis:

Flowrate = 30 gpm

 $C_{w,TCE} = 2,500 \text{ mg/L}$  in waterTCE Treatment Goal =  $5 \text{ mg/L}$ 

A low profile air stripper manufactured by  
North East Environmental Products, Inc.  
(603) 298-7061

Based on cumulative empirical laboratory  
data using pilot sized units, the  
following sizing was selected

Model 2331-P Low Profile Air Stripper

3 Tray Unit w/

3 HP, 1/60/230VAC Forced Air Draft Blower  
rated for 300 cfm @ 14 inches  $H_2O$   
in polyethylene construction

Design Details

- Air Water Ratio - 74.8
- Air Flow Rate - 300 cfm
- Inlet GW Temp -  $60^\circ\text{F}$
- Air Discharge Duct Size - 6"
- Air Velocity @ Duct -  $300 \text{ ft}^3/\text{min} = 1530 \frac{\text{ft}}{\text{min}}$
- Stack Discharge Temp -  $60^\circ\text{F}$
- TCE Removal Efficiency -  $\frac{\pi \left(\frac{3''}{12''}\right)^2}{99.9096\%}$

CALCULATION  
Form No. E-6 Rev. 12-89

**ENGINEERS**JOB NO. EV-12-001-01

SHEET 2 OF 3

Groundwater Extraction + Treatment System

Red Stone Arsenal, Alabama

Air stripper Sizing

DESIGNED BY NNADATE 2/15/96

CHECKED BY

DATE

TCE Concentration in Water Effluent?

$$E = \frac{C_{TCE,i} - C_{TCE,e}}{C_{TCE,i}}$$

$$\Rightarrow C_{TCE,e} = C_{TCE,i} - E C_{TCE,i}$$

where

 $C_{TCE,i}$  = influent concentration = 2,500 mg/L $E$  = removal efficiency = 99.9096%

$$C_{TCE,e} = 2,500 \text{ mg/L} - 0.999096 (2,500 \text{ mg/L})$$

$$C_{TCE,e} = 2.26 \text{ mg/L}$$

as a conservative estimate  $\Rightarrow$ 

$$C_{TCE,e} = 3 \text{ mg/L}$$

# ShallowTray™

low profile air strippers

## System Performance Estimate

### Client & Proposal Information:

ICF Kaiser  
 Site ID: Red Stone Arsenal, AL  
 Proposal #296712

Model chosen: 2300  
 Water Flow Rate: 30.0 gpm  
 Air Flow Rate: 300 cfm  
 Water Temp: 60.0 °F  
 Air temp: 50.0 °F  
 A/W Ratio: 74.8  
 Safety Factor: None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	Model 2331 Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
1,1-Dichloroethylene	3 ppb 2 ppb	<1 ppb 0.000043 95.7658%	<1 ppb 0.000045 99.9207%	<1 ppb 0.000045 99.9924%	<1 ppb 0.000045 99.9997%
Toluene	4 ppb 2 ppb	1 ppb 0.000045 84.6453%	<1 ppb 0.000059 97.6423%	<1 ppb 0.000060 99.6380%	<1 ppb 0.000060 99.9444%
Trichloroethylene	2500 ppb 5 ppb	242 ppb 0.033885 90.3323%	24 ppb 0.037156 99.0654%	3 ppb 0.037471 99.9096%	<1 ppb 0.037513 99.9913%

0.37 ppmv @ 300 CFM

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ICF KAISER ENGINEERS GROUP

ICF Kaiser Engineers, Inc.  
9300 Lee Highway  
Fairfax, VA 22031-1207  
703/934-3300 Fax 703/934-9740

**FAX**

Date:

2/16/96Number of pages in-  
cluding cover sheet:2

To:

Nora

From:

Nora

Fax Phone:

Fax Phone:

Phone:

Phone:

## Remarks:

☐ Urgent

For your review



Reply ASAP



Please comment

Nora,

Please replace page 2 of 2  
of Air Emissions calcs  
w/attached page

ThanksNora

This value 6.2 ppmv of TCE in offgas  
needs to added to Table 3-2.

ICF KAISER  
ENGINEERS

JOB NO. \_\_\_\_\_

SHEET 2 OF 2

Groundwater Extraction + Treatment Sys.

Red Stone Arsenal

Air Emissions

DESIGNED BY N/A DATE 2/15/9

CHECKED BY DATE

TCE concentration in off-gas?

$$C_{TCE, air} = \frac{m_{TCE}}{A.R. Flow}$$

$$m_{TCE} = 0.0375 \text{ lb/hr}$$

$$MW_{TCE} = 131.29 \text{ g/mole}$$

$$C_{TCE, air} = \frac{0.0375 \text{ lb/hr} \times \frac{1 \text{ mg}}{2.21 \times 10^{-9} \text{ lb}}}{300 \text{ ft}^3/\text{min} \times \frac{7.48 \text{ gal}}{\text{ft}^3} \times \frac{3.785 \text{ L}}{\text{gal}} \times 60 \text{ min/hr}}$$

$$= 33.3 \text{ mg/L}$$

. Need to convert to ppmV

$$MW_{TCE} = 131.29 \text{ g/mole}$$

$$V_{ideal} = 24.4 \text{ L/mole}$$

gas @ 60°

$$ppmV = \frac{33.3 \text{ mg TCE}}{L_{air}} \times \frac{\text{mole}}{131.29 \text{ g}} \times 24.4 \text{ L} \times \frac{\text{g}}{10^6 \text{ mg}}$$

6.18 ppmV

↑ @ 60°F, 1 atm  
ideal gas

TCE concentration = 6.2 ppmV  
in off-gas

**APPENDIX C**  
**MAJOR EQUIPMENT SPECIFICATIONS**

**TABLE C-1**  
**LIST OF MAJOR EQUIPMENT<sup>1</sup> TO BE SUPPLIED BY EQUIPMENT VENDOR<sup>2</sup>**  
**INTERIM GROUNDWATER REMEDIATION SYSTEM INSTALLATION**  
**REDSTONE ARSENAL, ALABAMA**

<b>TAG NO. (P&amp;ID)</b>	<b>QTY</b>	<b>EQUIPMENT DESCRIPTION</b>	<b>SPECIFICATIONS</b>	<b>MANUFACTURER/ MODEL NUMBER</b>
P-100	1	Stainless steel, environmental, submersible pump	4-inch diameter, 1 hp, 3450 rpm, 1/60/230V AC, rated for 15 gpm at 180 ft TDH, with teflon seals, 4-inch motor leads, and starting components within pump motor assembly.	Grundfos Model 16E9
P-200	1	Stainless steel, environmental, submersible pump	4-inch diameter, 1/2 hp, 3450 rpm, 1/60/230V AC, rated for 5 gpm at 180 ft TDH, with teflon seals, 4-inch motor leads, and starting components within pump motor assembly.	Grundfos Model 5E12
Equipment Shed	1	Pre-engineered wood/aluminum shed 10' x 15' with installed remediation equipment	One set of double doors with heating and lighting. Must be designed to meet building codes for installation in Redstone Arsenal, Alabama.	various
PCP	1	Process Control Panel to be located inside the equipment shed	Control System with Autodial Alarm Telemetry and Lightning Protection System. Panel shall be equipped with illuminated H.O.A. switches for all motors and electrically actuated valves and alarm indicators. To be supplied with power distribution panel, circuit breakers and single-point power source and telephone service connectors.	various

<sup>1</sup>Piping, fittings, valves and other components associated with the construction of the remediation system are excluded from this list. The vendor is responsible for assuring that the equipment required to meet the performance goals discussed in the Work Plan text and as depicted in the design drawings is supplied and constructed whether or not the equipment is listed here.

<sup>2</sup>Vendor shall verify the appropriateness of the specified equipment to meet the performance requirements set forth in the remedial action plan. Should alternate equipment be more economically or appropriately employed to accomplish the remedial objective, the vendor shall obtain approval of any such substitutions from the Engineer prior to implementation.

n/a not applicable

**TABLE C-1 (CONTINUED)**  
**LIST OF MAJOR EQUIPMENT TO BE SUPPLIED BY EQUIPMENT VENDOR**  
**INTERIM GROUNDWATER REMEDIATION SYSTEM INSTALLATION**  
**REDSTONE ARSENAL, ALABAMA**


TAG NO. (P&ID)	QTY	EQUIPMENT DESCRIPTION	SPECIFICATIONS	MANUFACTURER/ MODEL NUMBER
AS-100	1	Low profile air stripper	Skid Mounted air stripper with aeration trays, aerator blower, 6-inch air discharge duct, and integral sump tank (100 gallons minimum) in polyethylene construction. Available connection to discharge stack. Must meet contaminant removal parameters set in work plan. Power requirements - 1/60/230 VAC, 3 wire plus ground, 20 amp service. 6'H x 8'L x 4.4'W.	Northeast Environmental Products, Inc. Model 2331-P Shallow Tray
B-100	1	Air Stripper Blower	Operating flow of 300 cfm at 14" static water column pressure. Powered by 1/60/230 Volt, 3 HP, TEFC motors supplied with blower start/stop panel.	Supplied With Air Stripper
S-100	1	Air blower Silencer, Ambient Air	Inlet air blower silencer	Supplied With Air Stripper
BF-100	1	Blower Filter	Inlet Filter to aerator blower	Supplied With Air Stripper
PI-130	1	Vapor Pressure Indicator	Air Stripper Blower Effluent Pressure in inches of H <sub>2</sub> O	Supplied with Air Stripper
PSH-100	1	High Pressure Sensor	Vapor Pressure Sensor in inches of H <sub>2</sub> O	Supplied with Air Stripper
PAH-100	1	High Pressure Alarm	Low vapor pressure alarm.	Supplied with Air Stripper
FSL-100	1	Low Flow Sensor	Vapor Flow in cfm	Supplied with Air Stripper
FAL-100	1	Low Flow Alarm	Low flow alarm with local and remote alarm notification capabilities	Supplied With PCP
HS-050 HS-075	2	Groundwater extraction pumps disconnect switch	Manual override switch with <i>Hand-Off-Auto</i> settings	Supplied With PCP
HS-100	1	Hand switch for discharge transfer pump	Manual override switches with <i>Hand-Off-Auto</i> settings	To be supplied with control panel
HS-150	1	Hand switch for blower	Manual override switches with <i>Hand-Off-Auto</i> settings	Supplied with Air Stripper

n/a not applicable

**TABLE C-1 (CONTINUED)**  
**LIST OF MAJOR EQUIPMENT TO BE SUPPLIED BY EQUIPMENT VENDOR**  
**INTERIM GROUNDWATER REMEDIATION SYSTEM INSTALLATION**  
**REDSTONE ARSENAL, ALABAMA**

<b>TAG NO. (PAID)</b>	<b>QTY</b>	<b>EQUIPMENT DESCRIPTION</b>	<b>SPECIFICATIONS</b>	<b>MANUFACTURER/ MODEL NUMBER</b>
LSHL-050 LSHL-075	2	High-Low level sensors for extraction wells EX-01 and EX-02	High/low conductivity-based level sensing probes with intrinsically safe control signal	Warrick Controls
PI-050 PI-075 PI-100 PI-110 PI-120 PI-200 PI-250	7	Pressure gauge	0-100 psi of water pressure indicator, liquid filled, painted steel case $\pm$ 2%	various
FI-050 FI-075	4	Rotameter	Rotameter gauge readout of 0.5 - 50 gpm of water flow	various
FI-100/FQI-100 FI-200/FQI-200	2	Flow Meter	Flow quantity totalizer/indicator in cast iron construction rated for 3 to 200 gpm, helical vane inferential meter. Supply with companion flanges for NPT connection.	Kent Meters, Inc. T-3000 CI
TI-100 TI-200	2	Temperature Gauge	Temperature indicator, range of -20 to 120°F, painted steel case	various
F-100	1	Particulate Filter	Single carbon steel filter housing unit, 2-inch NPT with one pleated bag filter and 6 spare pleated bag filters.	Rosedale Products, Inc. Model 8
LSHL-100 LSHH-100	1	High-Low and High-High float level switch for air stripper sump tank	Reed Float Switch w/ Epoxy Coated Die Cast Aluminum Housing.	Warrick Series 16 Supplied with Air Stripper
LAHH-100	1	Level High-High Alarm	Local and remote autodial alarm of high-high water level in air stripper sump tank	Supplied with PCP
P-300	1	Centrifugal Transfer Pump	Cast iron bronze fitted centrifugal pump with 5 HP, 3600 rpm, 3/60/230 VAC, TEFC motor capable of 50 gpm @ 144 feet TDH, 5.98" impeller diameter, T.21 Viton mechanical seal, and 1" x 1.5" NPT connections.	Price Pump Co. Model A100-1"x1.5"x6"

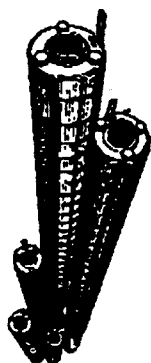
Key: n/a not applicable

	<b>GRUNDFOS</b>	<b>Redi-Flo Environmental Submersible Pumps</b>	<b>16E</b>

# Submittal Data

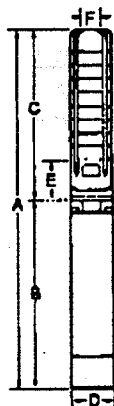
# 3450 RPM

# 60 Cycle


**JOB or CUSTOMER:**
**ENGINEER:**
**CONTRACTOR:**
**SUBMITTED BY:**
**DATE:**
**APPROVED BY:**
**DATE:**
**ORDER NO.:**
**DATE:**
**SPECIFICATION REF.:**

QUANTITY	TAG NO.	MODEL NO.	GPM	FEET	VOLT	PHASE	COMMENT

## Dimensions



## Technical Data

**FLOW RANGE:** 10 to 20 US GPM

**MOTORS:** Grundfos MS402E Environmental Submersible Motor (Standard)

**Maximum Operating Temperature:** 104°F (40°C)

**Maximum Operating Pressure:** 220 PSI

**Maximum Number of Starts Per Hour:** 100

**Minimum Recommended Flow Past Motor:** 0.25 ft/sec

**(NOTE:** Franklin Pollution Recovery motor is optional.)

**DISCHARGE SIZE:** 1 1/4" NPT

**PUMP END CONSTRUCTION MATERIALS:** Stainless Steel and Teflon®

**INSTALLATION:** Unit to be installed vertically for submerged operation.

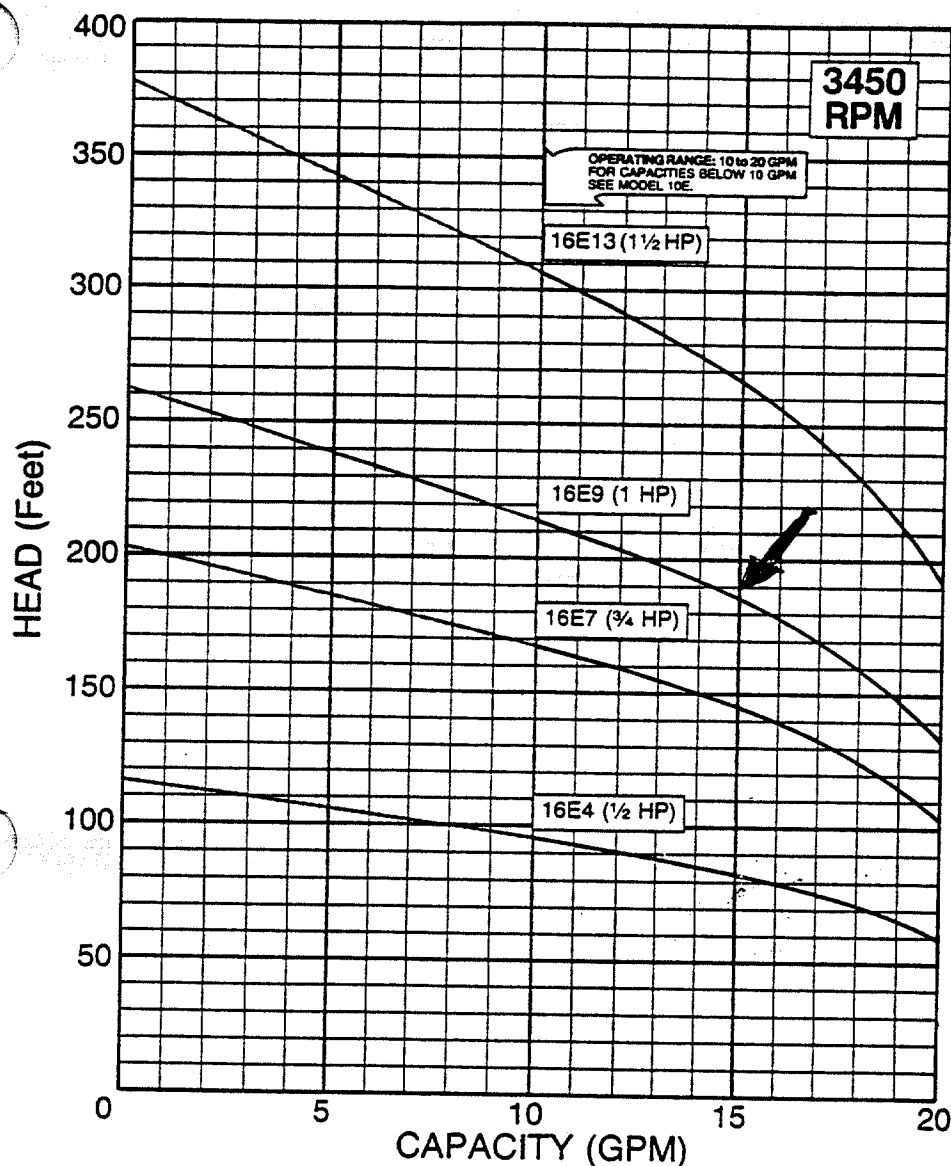
## Electrical Data, Dimensions, and Weights ①

PUMP TYPE	MOTOR				DIMENSIONS (In Inches)						NET WEIGHT (LBS.)②	SHIP WEIGHT (LBS.)②
	HP	SF	PH	VOLTS	OVERALL LENGTH A	MOTOR LENGTH B②	PUMP END LENGTH C	MAX. DIA. D	INLET E	DISCH. PIPE SIZE (NPT) F		
16E4	1/4	1.00	1	230	20 1/4	10 3/4	10 3/4	3 1/2	3 1/4	1 1/4	27	28
16E7	3/4	1.50	1	230	23 1/4	11 3/4	11 3/4	3 3/4	3 1/4	1 1/4	33	34
16E9	1	2.00	1	230	25 1/4	12 3/4	12 3/4	3 3/4	3 1/4	1 1/4	33	34
16E13	1 1/2	1.30	1	230	30 7/8	13 1/4	16 7/8	3 3/4	3 1/4	1 1/4	33	34

① Data for Grundfos MS402E motors. ② Does not include motor leads.

## Performance Curves

Redi-Flo Enviromental Pump



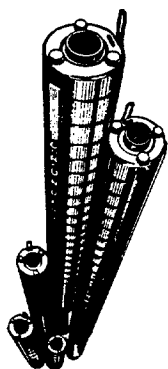
## Materials of Construction

REDI-FLO PUMP END	
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Check Valve Seal	304 Stainless Steel & Teflon
Diffuser Chamber	304 Stainless Steel
Impeller Seal Ring	Teflon
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Guard	304 Stainless Steel
Coupling	329/420/431 Stainless Steel
Shaft	304 Stainless Steel
Guard	304 Stainless Steel
Inducer	304 Stainless Steel
Intermediate Bearings	Teflon®

NOTE: Specifications are subject to change without notice.

GRUNDFOS ENVIRONMENTAL MOTOR	
Nema Torc	304 Stainless Steel
Studs & Fasteners	304 Stainless Steel
Nuts	316 Stainless Steel
Sand Slinger	Viton®
Shaft Extension	431 Stainless Steel
Diaphragm	Viton®
Stator Housing	304 Stainless Steel
Fill Plug Screw	304 Stainless Steel
Fill Plug Washer	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR LEADS	
Connector Sleeve	304 Stainless Steel
Connector Potting	Scotch Cast #4® Epoxy w/Viton® Cap
Connector Ring	Viton®
Lead Insulation	Teflon®

**GRUNDFOS®****Redi-Flo4  
Environmental  
Submersible Pumps****5E****Submittal Data****3450 RPM****60 Hertz**

JOB or CUSTOMER:

ENGINEER:

CONTRACTOR:

SUBMITTED BY:

DATE:

APPROVED BY:

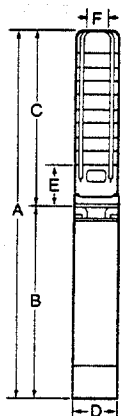
DATE:

ORDER NO.:

DATE:

SPECIFICATION REF.:

QUANTITY	TAG NO.	MODEL NO.	GPM	FEET	VOLT	PHASE	COMMENT

**Dimensions****Technical Data**

FLOW RANGE: 1.2 to 7 US GPM

MOTORS: Grundfos MS402E Environmental Submersible Motor (Standard)

**Maximum Operating Temperature: 104°F (40°C)****Maximum Operating Pressure: 220 PSI****Maximum Number of Starts Per Hour: 100****Minimum Recommended Flow Past Motor: 0.25 ft/sec**

(NOTE: Franklin Pollution Recovery motor is optional.)

DISCHARGE SIZE: 1" NPT

PUMP END CONSTRUCTION MATERIALS: Stainless Steel and Teflon®

INSTALLATION: Unit to be installed vertically for submerged operation.

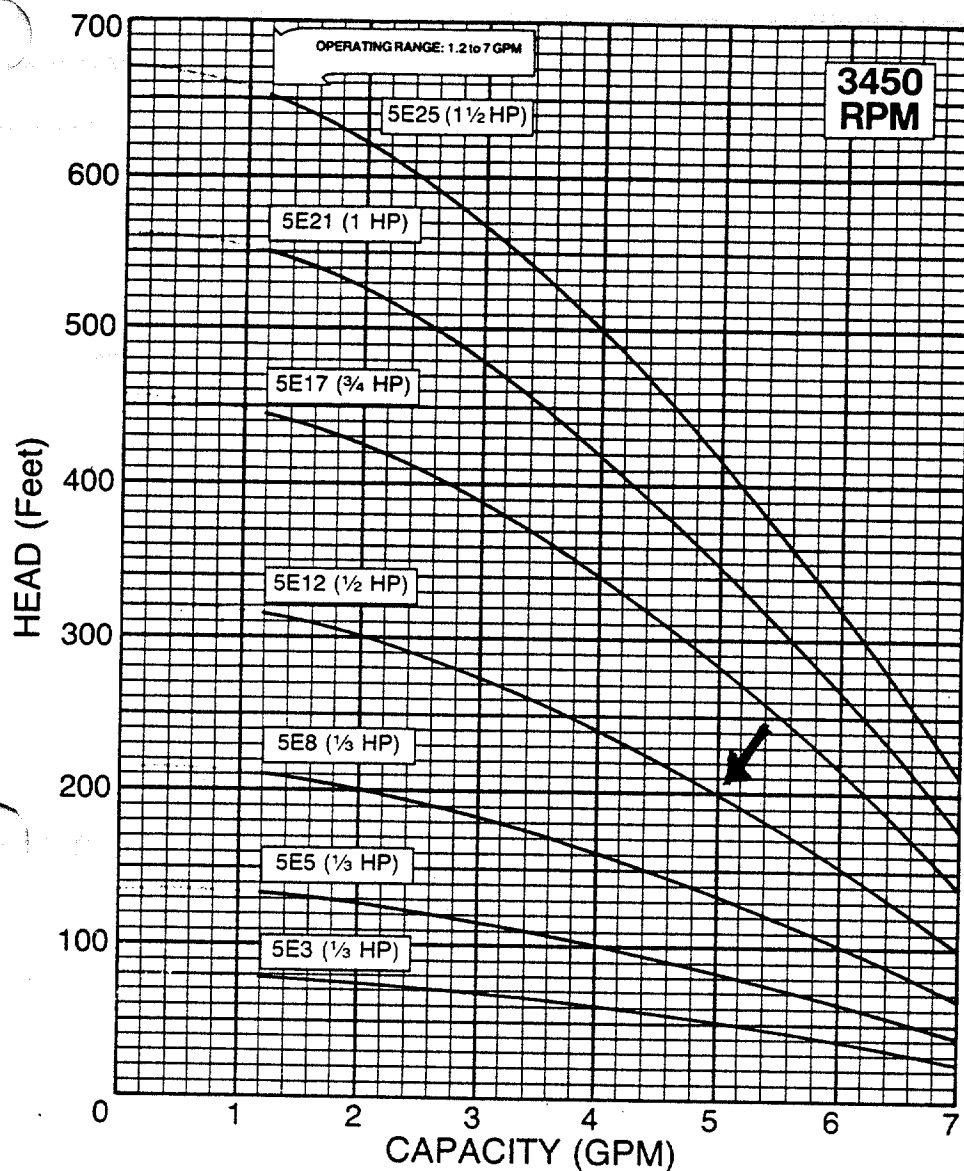
**Electrical Data, Dimensions, and Weights ①**

PUMP TYPE	MOTOR				DIMENSIONS (In Inches)						NET WEIGHT (LBS.)②	SHIP. WEIGHT (LBS.)②
					OVERALL LENGTH A	MOTOR LENGTH B①	PUMP END LENGTH C	MAX. DIA. D	INLET E	DISCH. PIPE SIZE (NPT) F		
5E3	1/3	1.75	1	230	18 9/16	10	8 9/16	3 31/32	3 1/4	1	23	25
5E5	1/3	1.75	1	230	20 5/16	10	10 5/16	3 31/32	3 1/4	1	24	26
5E8	1/3	1.75	1	230	22 3/4	10	12 3/4	3 31/32	3 1/4	1	26	28
5E12	1/2	1.60	1	230	26 13/16	10 13/16	16	3 31/32	3 1/4	1	28	29
5E17	3/4	1.50	1	230	31 7/16	11 3/8	20 3/16	3 31/32	3 1/4	1	31	32
5E21	1	1.40	1	230	35 7/16	12	23 7/16	3 31/32	3 1/4	1	33	35
5E25	1 1/2	1.30	1	230	40 5/16	13 9/16	26 3/4	3 31/32	3 1/4	1	35	37

① Data for Grundfos MS402E motors. ② Does not include motor leads.

## Performance Curves

**5E**  
Redi-Flo4 Environmental Pump



## Materials of Construction

REDI-FLO4 PUMP END	
Check Valve Housing	304 Stainless Steel
Check Valve	304 Stainless Steel
Check Valve Seat	304 Stainless Steel & Teflon®
Diffuser Chamber	304 Stainless Steel
Impeller Seal Ring	Teflon®
Impeller	304 Stainless Steel
Suction Interconnector	304 Stainless Steel
Inlet Screen	304 Stainless Steel
Pump Shaft	304 Stainless Steel
Coupling	329/420/431 Stainless Steel
Shafts	304 Stainless Steel
Guard	304 Stainless Steel
Ag Inducer	304 Stainless Steel
Intermediate Bearings	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR	
Nema Top	304 Stainless Steel
Studs & Fasteners	304 Stainless Steel
Nuts	316 Stainless Steel
Sand Slinger	Viton®
Shaft Extension	431 Stainless Steel
Diaphragm	Viton®
Stator Housing	304 Stainless Steel
Fill Plug Screw	304 Stainless Steel
Fill Plug Washer	Teflon®

GRUNDFOS ENVIRONMENTAL MOTOR LEADS	
Connector Sleeve	304 Stainless Steel
Connector Potting	Scotch Cast #4® Epoxy w/Viton® Cap
Connector Plug	Viton®
Lead Insulation	Teflon®

NOTE: Specifications are subject to change without notice.

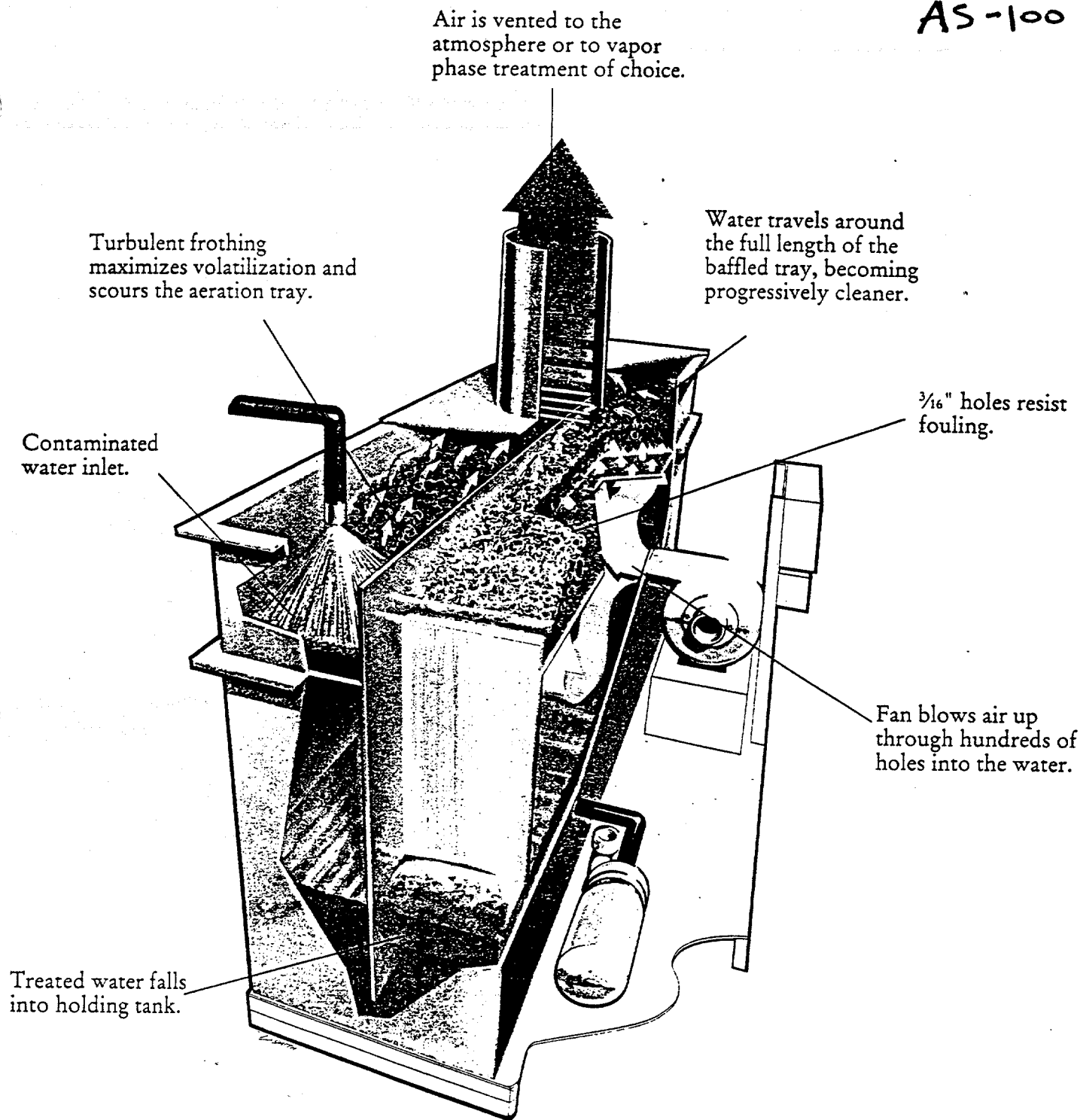
GRUNDFOS Pumps Corp. • 2555 Clovis Ave. • Clovis, CA 93612  
Support Centers: Allentown, PA • Atlanta, GA

L-RF4-TL-005 10/26/92  
PRINTED IN USA

DALE 2 OF 2

# The ShallowTray Process

AS-100



*This illustration is representative of the ShallowTray® Model 2611.*

Protected under U.S. Patent Nos. 5,045,215 and 5,240,595. Other International Patents Pending.

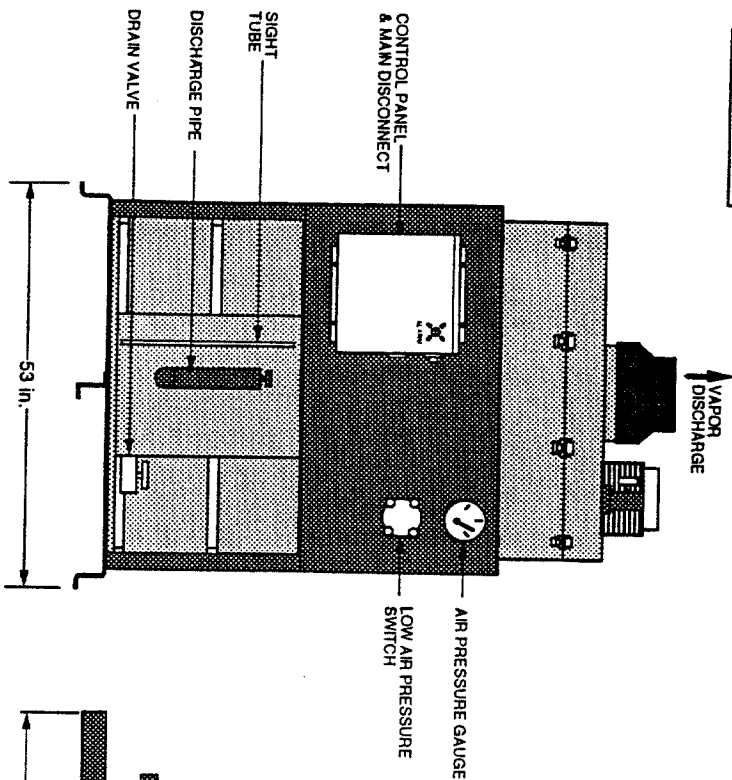
Photo on front cover: top view of 2300 Series aeration tray in action.  
Photo on back cover: cross section of a ShallowTray in action.  
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Our policy is one of continual improvement and we reserve the right to alter any detail of our products at any time without notice.

Printed on recycled paper  
5494

PAGE 1 OF 3

MINIMUM CLEARANCE	
FRONT	1.5 ft.
TOP	12 in.
REAR	1.5 ft.
LEFT	2 ft.
RIGHT	2 ft.

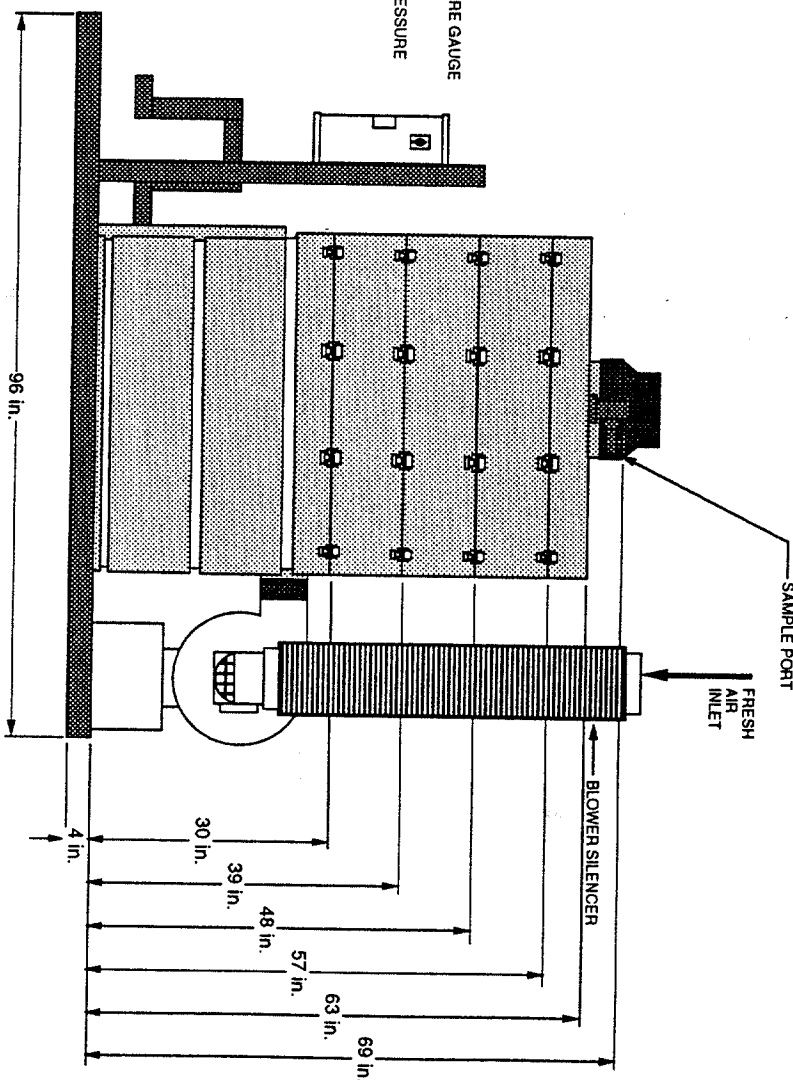
## FRONT



- BASIC SYSTEM**
- ✓ SUMP TANK
  - ✓ STRIPPER TRAYS
  - ✓ BLOWER
  - ✓ MIST ELIMINATOR
  - ✓ PIPING
  - ✓ SPRAY NOZZLE
  - ✓ WATER LEVEL SIGHT TUBE
  - ✓ GASKETS
  - ✓ LATCHES

- OPTIONAL ITEMS**
- ✓ FRAME
  - ✓ AIR PRESSURE GAUGE
  - ✓ DISCHARGE PIPING
  - ✓ DISCHARGE PUMP
  - ✓ FEED PUMP
  - ✓ ADDITIONAL BLOWER
  - ✓ EXPLOSION-PROOF MOTOR(S)
  - ✓ BLOWER START/STOP PANEL
  - ✓ CONTROL PANEL
  - ✓ MAIN DISCONNECT SWITCH
  - ✓ I.S. COMPONENTS/REMOTE MOUNT
  - ✓ INTERMITTENT OPERATION
  - ✓ STROBE LIGHT
  - ✓ ALARM HORN
  - ✓ POWER LAMP INDICATOR
  - ✓ LOW AIR PRESSURE ALARM SWITCH
  - ✓ HIGH WATER LEVEL ALARM SWITCH
  - ✓ DISCHARGE PUMP LEVEL SWITCH
  - ✓ WATER PRESSURE GAUGE(S)
  - ✓ DIGITAL WATER FLOW INDICATOR
  - ✓ AIR FLOW METER
  - ✓ TEMPERATURE GAUGE(S)
  - ✓ LINE SAMPLING PORTS
  - ✓ AIR BLOWER SILENCER
  - ✓ WASHER WAND
  - ✓ AUTO DIALER

## RIGHT SIDE



### NOTE:

1. DRAWING REPRESENTS A UNIT TYPICAL OF THE SPECIFICATION YOU REQUESTED. MINOR CHANGES MAY RESULT IN THE MANUFACTURING PROCESS.

### CONNECTION INFORMATION

ITEM	SIZE
GRAVITY DISCHARGE	2 in. Ø SOCKET, PVC90
DISCHARGE PUMP	3/4 in. Ø FNPT
WATER INLET	1-1/4 in. Ø FNPT
AIR EXHAUST NOZZLE	8 in. Ø STUB W/8-6 CPLG

**POWER:** 1Ø, 230 Volts, 3 WIRE + GROUND  
\*CONSULT N.E.E.P. FOR CAPACITIES AND OTHER VOLTAGE OPTIONS



NORTH EAST ENVIRONMENTAL PRODUCTS, INC.  
17 TECHNOLOGY DRIVE  
WEST LEBANON, NEW HAMPSHIRE 03784  
PHONE: 603-285-7061 FAX: 603-285-7063

DRAWING NAME:

ShallowTray® Model 2331-P

DRAWING #:

Proposal #296712

DRAWN: EB

CUSTOMER:

ICF KAISER

DATE: 2/8/96

SCALE: NTS

SIZE: A

1 OF 1

# ShallowTray™

low profile air strippers

## System Performance Estimate

### Client & Proposal Information:

ICF Kaiser  
 Site ID: Red Stone Arsenal, AL  
 Proposal #296712

Model chosen: 2300  
 Water Flow Rate: 30.0 gpm  
 Air Flow Rate: 300 cfm  
 Water Temp: 60.0 °F  
 Air temp: 50.0 °F  
 A/W Ratio: 74.8  
 Safety Factor: None

Contaminant	Untreated Influent Effluent Target	Model 2311 Effluent Water Air(lbs/hr) % removal	Model 2321 Effluent Water Air(lbs/hr) % removal	<b>Model 2331</b> Effluent Water Air(lbs/hr) % removal	Model 2341 Effluent Water Air(lbs/hr) % removal
1,1-Dichloroethylene	3 ppb 2 ppb	<1 ppb 0.000043 95.7658%	<1 ppb 0.000045 99.8207%	<1 ppb 0.000045 99.9924%	<1 ppb 0.000045 99.9997%
Toluene	4 ppb 2 ppb	1 ppb 0.000045 84.6453%	<1 ppb 0.000059 97.6423%	<1 ppb 0.000060 99.6380%	<1 ppb 0.000060 99.9444%
Trichloroethylene	2500 ppb 5 ppb	242 ppb 0.033885 90.3323%	24 ppb 0.037156 99.0654%	3 ppb 0.037471 99.9096%	<1 ppb 0.037513 99.9913%

0.37 ppmv @ 300 CFM

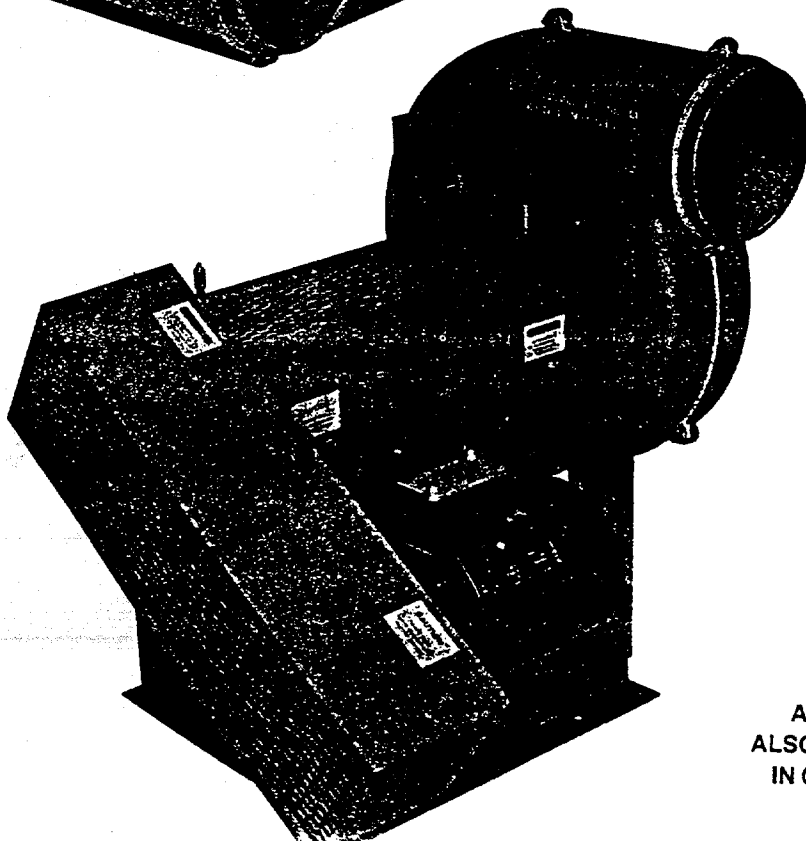
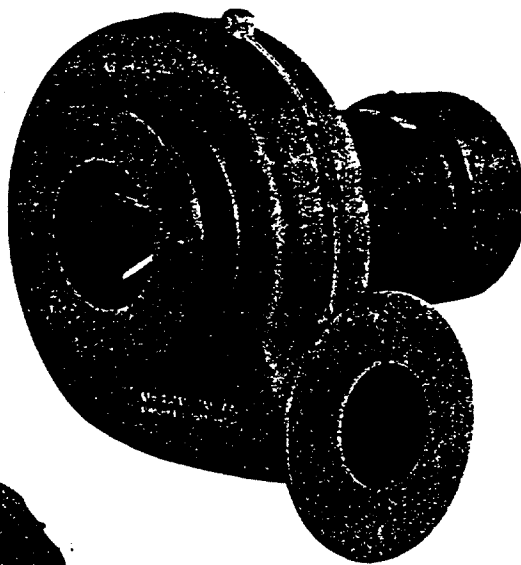
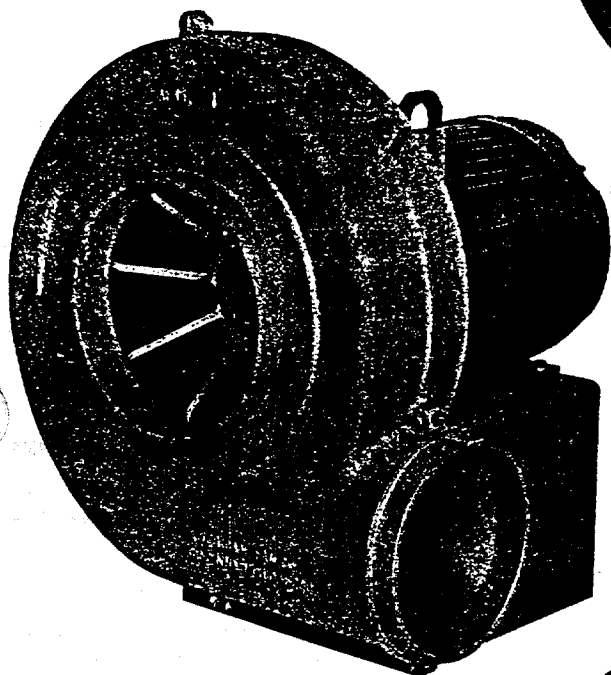
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# AMERICAN FAN COMPANY®

2933 Symmes Road, Fairfield, Ohio 45014  
Phone: (513) 874-2400 Fax: (513) 870-5577

DESIGNERS/  
MANUFACTURERS OF  
HIGH EFFICIENCY  
FANS/BLOWERS/  
DUST COLLECTORS



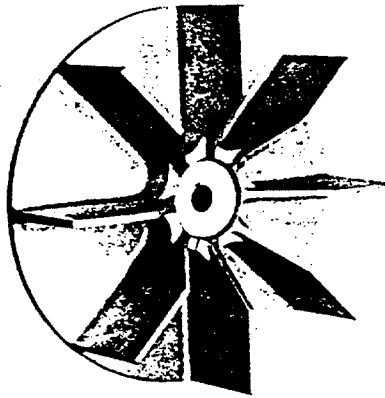
ALL UNITS  
ALSO AVAILABLE  
IN CAST IRON

B-100

# AT CAST MINIM PRESSURE BLOWERS

PAGE 1 OF 3

## FEATURES



AF Wheel

Model AF features a rugged, lightweight and rustproof cast aluminum housing and wheel making it ideal for demanding industrial applications. Model AF is available in direct or belt drive with a variety of accessories to meet your requirements.

Capacity selections are available up to 3600 CFM and pressure selections up to 20" SP w.g.

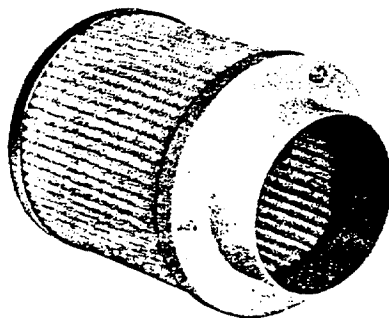
- Split housing for maintenance ease
- Ever O.D. pipe sizes on inlet and outlet
- Non-sparking cast aluminum wheel and housing
- Assortment of wheel sizes to pinpoint your performance requirement
- Reliability
- Wheels both statically and dynamically balanced
- Rustproof
- Low initial cost
- Available in arrangements 1, 2, 4, 8 and 9

## APPLICATIONS

- Rubber processing
- Food processing
- Chemical processing
- Fume control
- Dust control
- Combustion air for incinerators, ovens, furnaces, kilns and dryers
- Cooling electronic equipment, motors, generators and transformers
- Paper and printing machinery
- Textile machinery
- Light materials conveying
- Woodworking machinery
- Forced drying

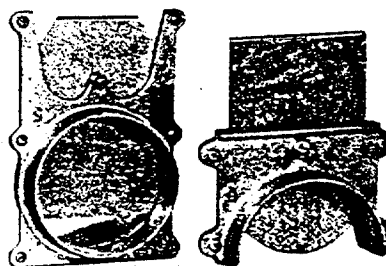
## OPTIONS

- Inlet flange
- Outlet flange
- Housing drain
- Corrosive resistant coatings
- Inlet and/or outlet guard
- Cast iron housing
- Fabricated steel wheel
- Fabricated stainless wheel and housing
- Shaft seal
- Sound attenuator
- Inlet filter
- Full or half cut-off
- Heat slinger
- Drive guard system



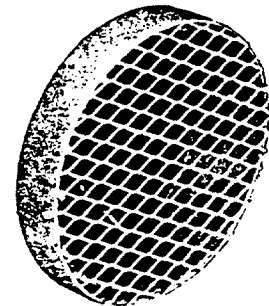
### INLET FILTER

Oil wetted, crimped steel wire mesh media provides 94% filtration efficiency of particulate of 10 micron or larger. Filters are cleanable and reusable.



### FULL and HALF CUT-OFF

Cast aluminum housing with galvanneal steel gate allows manual adjustment of CFM. Thumbscrew locks gate in place. Can be mounted on either inlet or outlet side of blower.



### INLET GUARD

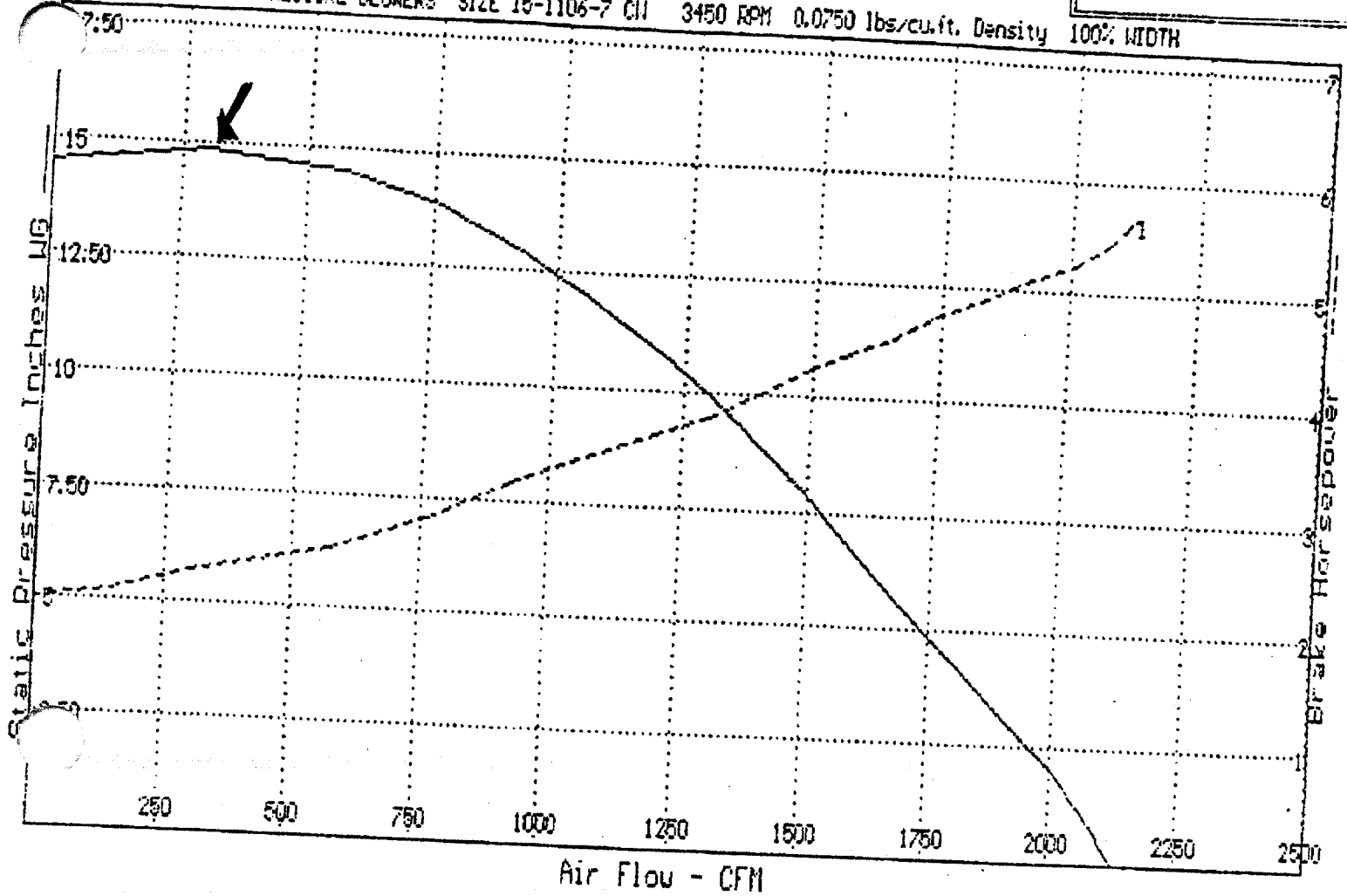
Expanded metal welded to collar that is bolted to inlet of blower. Provides OSHA guarding on non-ducted inlet applications while preventing foreign objects from entering blower.

# American Fan Company / Woods USA

AF PRESSURE BLOWERS SIZE 15-1106-7 CII 3450 RPM 0.0750 lbs/cu.ft. Density 100% WIDTH

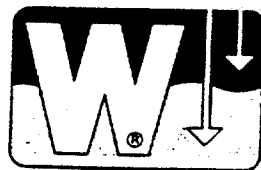
NEEP #

10G. 10G1



Prepared For :  
NORTH EAST ENVIRONMENTAL PRODUCTS  
1331, EXP 1331, 2331, EXP 2331

04/07/1992



WARRICK  
CONTROLS

FORM 270-B

LS#L-050

LS#L-075

# Installation

## INSTALLATION OF WARRICK SERIES 27 — INTRINSICALLY SAFE SENSING CIRCUIT

This bulletin should be used by experienced personnel as a guide to the installation of the Series 27. Selection or installation of equipment should always be accomplished by competent technical assistance. We encourage you to contact Warrick or its local representative if further information is required.

### IMPORTANT: BEFORE PROCEEDING TO INSTALL AND WIRE THE CONTROL, READ AND THOROUGHLY UNDERSTAND THESE INSTRUCTIONS.

When installed according to these instructions, this device provides an intrinsically safe output for interface into Class I and II, Division I, Groups A, B, C, D, E, F, and G Hazardous locations. Electrical equipment connected to associated apparatus should not exceed maximum voltage marked on product.

**LOCATION:** The control must be situated in a non-hazardous area where an explosive atmosphere will not exist at any time unless it is mounted in a suitable U.L. approved explosion-proof enclosure with suitable U.L. approved explosion-proof seals.

### WIRING:

1. Intrinsically safe wiring must be kept separate from non-intrinsically safe wiring.
2. Intrinsically safe and non-intrinsically safe wiring may occupy the same enclosure or raceway if they are at least 2 inches (50mm) apart and separately tied down. Inside panels, field wiring terminals for intrinsically safe circuits must be separated by at least 2 inches (50mm) from non-intrinsically safe terminals.
3. Wire the control device(s) to the Series 27 relay as shown in the specific application wiring diagram on reverse side. A separate rigid metallic conduit should be used to enclose the conductors of the intrinsically safe control circuit.
4. An approved seal should be used at the point where the intrinsically safe control circuit wiring enters the hazardous area.

For intrinsically safe output wiring use #14 or #16 AWG type MTW or THHN wire. By using these wire types in conjunction with the following distance recommendations, you will not exceed the maximum capacitance for field wiring.

Use the following chart as a guide for maximum wire runs for differential level service (3 wire) field wiring.

Model	Max. Sensitivity (K OHMS)	Distance (Ft.)
27XXDO	3	4,000
27XXEO	10	900
27XXGO	100	75

**GROUNDING:** Both mounting tabs of the Series 27 provide an electrical connection for earth grounding between the control's internal solid state circuitry and the enclosure chassis. To insure proper ground-

ing, use only metal screws and lock washers when mounting this control.

One of the two ground terminals provided on the intrinsically safe output terminal strip must be connected as reference to the same conductive media presented to terminals "H" and "L" (see applicable wiring diagram on reverse side).

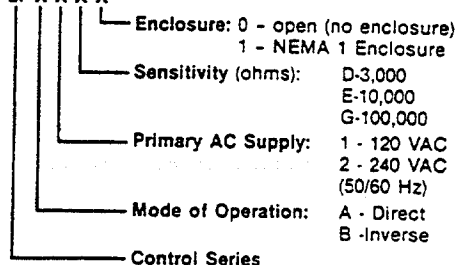
Terminal G1 on the supply line/load side terminal strip is a redundant system ground terminal and should be connected to the earth ground buss of the control's AC supply line feeder.

### NOTE:

1. Intrinsically safe terminals can be connected to any non-energy generating or storing switch device such as a pushbutton, limit or float type switch or any Warrick electrode and fitting assembly.
2. To prevent electrical shock from supply line/load side powered connections, the Series 27 should be mounted in a tool accessible enclosure of proper NEMA rated integrity.
3. For additional guidance on "Hazardous Location Installations" and "Intrinsically Safe Devices", consult ANSI/ISA standard RP 12-6 or NEC articles 500 through 516.

### MODEL NUMBER DESIGNATION:

SERIES 27 X X X X



## SPECIFICATIONS

**CONTACT DESIGN:** SPDT (1 form C), one normally open (N.O.) and one normally closed (N.C.)

**CONTACT RATING:** 8 Amps - 250 VAC, 8 Amps - 30 VDC. Resistive.

**CONTACT LIFE:** Electrical @ rated load = 100,000 cycles minimum. Mechanical = 10,000,000 cycles.

**ELECTRONICS MODULE:** Solid state components epoxy encapsulated in a black nylon shell.

**SENSITIVITY RANGE:** 0-100,000 Ohms maximum specific resistance.

**TEMPERATURE RANGE:** (minus) -40 deg F. to (plus) + 150 deg F.

**PRIMARY AC SUPPLY LINE:** A) Voltage — (120, and 240 VAC) (plus) + 10%, (minus) — 10%. B) Frequency — 50/60 Hertz. C) Power — (Relay energized) 1.7 VA.

**SECONDARY CIRCUIT:** Nominal 11 Volts. AC, RMS, Current: 2.3 Milliampere, RMS.

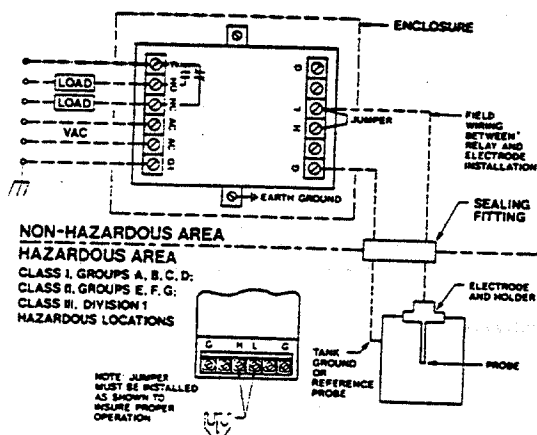
**TERMINALS:** Size 6 pan head screws with captivated wire clamping plate.



# INSTALLATION OF WARRICK SERIES 27 — INTRINSICALLY SAFE SENSING CIRCUIT

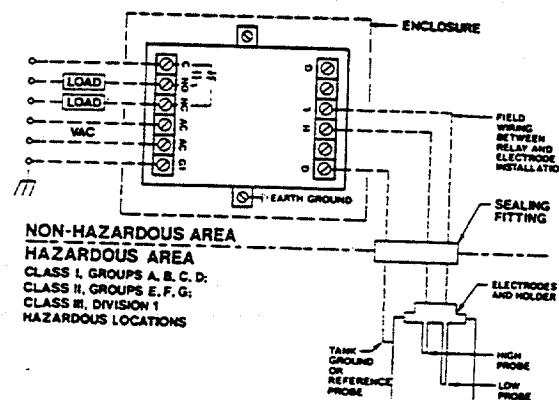
## SINGLE LEVEL SERVICE — CONDUCTANCE ACTUATED:

Connect incoming AC (120, 240 VAC) supply to AC terminals:  
Incoming earth ground to terminal G1.  
Install metallic jumper between terminals H-L.  
Connect terminal L to the electrode.  
Terminal G must be grounded to the tank if metallic. When the tank is non-metallic, terminal G must be connected to an additional electrode of length equal to the longest electrode.  
NOTE: Jumper must be installed as shown to insure proper operation. Wire contacts (C-NO) normally open and (C-NC) normally closed into load circuit as required.



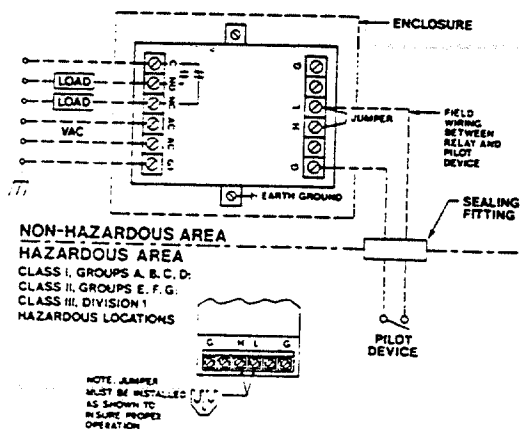
## DIFFERENTIAL LEVEL SERVICE — CONDUCTANCE ACTUATED:

Connect incoming AC (120, 240 VAC) supply to AC terminals:  
Incoming earth ground to terminal G1.  
Connect terminal H to high electrode and terminal L to low electrode.  
Terminal G must be grounded to the tank if metallic. When the tank is non-metallic, terminal G must be connected to an additional electrode of length equal to the longest electrode.  
Wire contacts (C-NO) normally open and (C-NC) normally closed into load circuit as required.



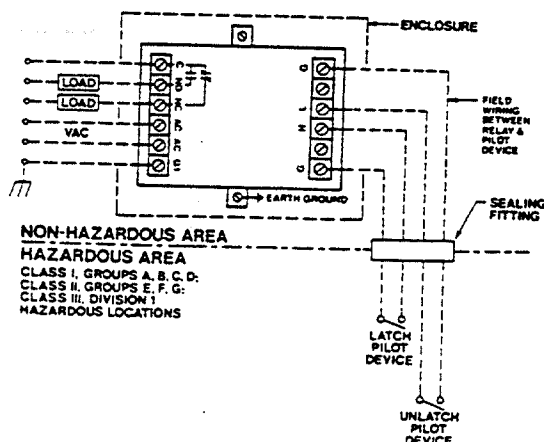
## SINGLE INPUT (NON-LATCHING) - PILOT CONTACT ACTUATED:

Connect incoming AC (120, 240 VAC) supply to AC terminals:  
Incoming earth ground to terminal G1.  
Install metallic jumper between terminals H-L.  
Wire contacts (C-NO) normally open and (C-NC) normally closed into load circuits as required.  
Connect the pilot contact to terminals G-L.  
NOTE: Jumper must be installed as shown to insure proper operation.



## DUAL INPUT (LATCHING) - PILOT CONTACT ACTUATED:

Connect incoming AC (120, 240 VAC) supply to AC terminals:  
Incoming earth ground to terminal G1.  
Wire contacts (C-NO) normally open and (C-NC) normally closed into load circuits as required.  
Connect the latch pilot contact to terminals G-H and the unlatch pilot contact to terminals G-L.



# Specification Sheet

## Kent Turbine Meters Model T-3000 Bronze, Magnetic Drive, Round Flanged Ends

FI-100 / FQI-100  
FI-200 / FQI-200

Sizes 1 1/2", 2" & 3"



T3000CP



T3000CB

### Description

**Operation.** The T-3000 Turbine Meter is designed for installation where occasional low and moderate to high sustained flows are demanded. Water passes through the meter without a change in flow direction, driving a helix rotor in direct proportion to the quantity of water passing through the meter. Rotor revolutions are transferred to a register by appropriate reduction gearing and a magnetic drive.

**Compliance to Standards.** The T-3000 Turbine Meter complies with all performance and material requirements of the American Water Works Association Standard C-701, Class II In-Line (High-Velocity) Type, as most recently revised.

**Installation.** The meter must be installed in a clean pipeline, free from any foreign materials. Install the meter with direction of flow as indicated by the arrow cast in the meter case. The meter may be installed in horizontal or inclined lines. It is recommended that a Kent Plate Strainer be used to protect the turbine and help reduce the effects of turbulence.

**Application.** The meter is for use in **POTABLE COLD WATER** up to 120 ° F (50 ° C) and working pressures up to 150 psi. The meter will perform with accuracy registration of 100% ± 1 1/2% within the

### Specifications

Size:	1 1/2"	2"	3"
95%-101% Accuracy GPM	2.99	2.99	4
*98.5%-101.5% Accuracy GPM	4-200	4-200	5-750
Continuous Flow GPM	160	160	600
Maximum Flow GPM	200	200	750
Operating Pressure psi	150	150	150
Operating Temperature °F	120	120	120

#### Sweep Hand Registers

US Gallons	100	100	100
Cubic Feet	10	10	10
m³ - Cubic Meters	1	1	1
Imperial Gallons	100	100	100

#### Capacity of Register

US Gallons (millions)	100	100	100
Cubic Feet (millions)	10	10	10
m³ Cubic Meters (millions)	1	1	1
Imperial Gallons (millions)	100	100	100

#### Register Type

Permanently sealed direct reading register.

#### Materials

Main Case	Bronze
Top Cover Plate	Bronze or Polymer
Body O-Ring	Neoprene Rubber
Case Bolts	Stainless Steel
Measuring Element	Polyphenylene Oxide
Rotor	Polypropylene
Rotor Bushings	PTFE Compound
Rotor Thrust Bearing	Ceramic Jewel
Rotor Spindle	Tungsten Carbide
Undergearing	Polycrystal Resin
Register Lens	Tempered Glass
Register Housing and Lid	Synthetic Polymer or Bronze
Register Can	90% Copper Alloy

**Kent Meters, Inc.**  
An ABB Kent Meter Division Company

**ABB**

normal flows". Both pressure loss and accuracy tests are made before shipment. No adjustments need be made before installation.

**Construction.** The meter consists of a main case, a measuring element, a case cover and a magnetically driven register assembly. The main case is cast in bronze with raised characters showing model, size and direction of flow. The case has a threaded inlet. A case dowel pin is inserted for locating the top cover plate. The measuring element assembly consists of the rotor, straightening vanes, accuracy regulator, spindles and gears, filters and undergear assembly. The measuring element is attached to the underside of the cover with four stainless steel screws and washers, one insert of which is placed eccentrically in the cover. The internal regulator assembly is interconnected with an external regulator shaft located on top of the cover allowing meter calibration without depressurizing the test bench or meter service. The regulator is protected by a tamperproof device. The main case and cover are assembled with an O-ring gasket and stainless steel bolts. The register assembly is secured to the main case with a tamperproof screw and is hinged over the inlet throat. However, the register can be rotated and locked in any 360 degree position therein.

**Register.** The register is contained within a 90% copper seamless can which is vacuum purged then filled with a dry nitrogen gas to eliminate condensation. The 1/4" true tempered glass lens is secured in an "L" shaped gasket, then roll sealed to produce a permanent sealed design. To assure easy reading, the totalizer wheels are large and color coded. The applicable size, model, registration, part number and date code are printed on the calibrated dial

face. Moving clockwise during operation, the extra thin sweep hand does not interfere with meter reading, and the flow indicator will detect plumbing leaks.

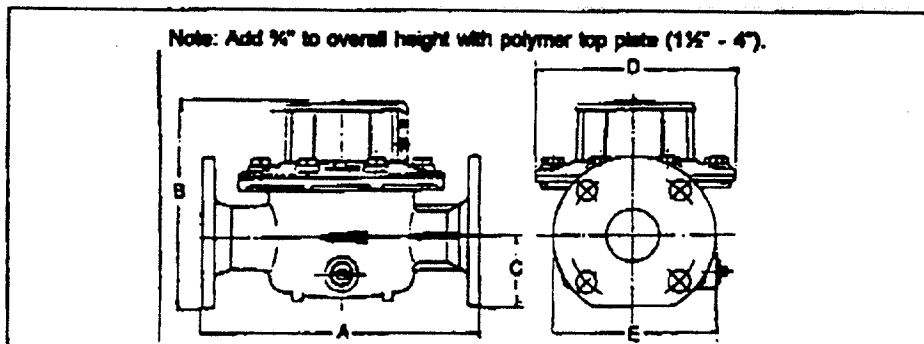
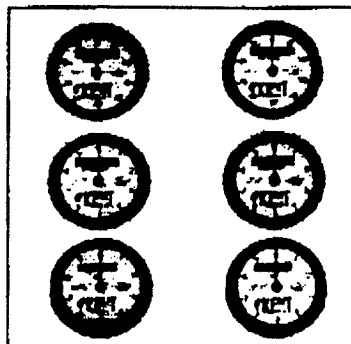
**Magnetic Drive.** The magnetic drive design eliminates miscoupling associated with right angle drives. Torque is absorbed in the undergear assembly below the driving magnet. Consequently, the driving magnet at all flows is turning slowly, assuring magnetic coupling with the register assembly. The undergearing is protected by an encasement appropriately filtered.

**Connections.** The 1 1/2", 2" & 3" meters are available with 4-bolt round flanged end connections. The flanged connections conform to ANSI B16.1 cast-iron pipe flange, Class 125. Both bronze and cast-iron companion flanges are available. The companion flanges are faced, drilled and tapped with ANSI B2.1 internal taper pipe thread and conform to ANSI B16.1 cast-iron pipe flange, Class 125.

**Pulsers.** See Specification Sheet #LRP/HRP-T3000. LRP (2-wire) Reed Switch, 4 Watt (50V AC/DC Max.) HRP (3-wire) Slotted Disc, 6-15 VDC Both units require power from an external source.

Dimensions and Net Weights

Meter Size	Dimensions (inches)					Weight (lbs.)
	A	B	C	D	E	
1 1/2" Oval	10	7 3/4	2 7/16	7 3/8	5 3/8	19 1/2
1 1/2" Round	10	7 3/4	2 7/16	7 3/8	5 1/16	20
2" Oval	10	7 3/4	2 7/16	7 3/8	6 1/8	21 1/2
2" Round	10	7 7/8	2 9/16	7 3/8	6 1/16	22
3"	12	9 3/8	3 13/16	7 3/8	7 1/2	33 3/8



**ABB**

The company's policy is one of continuous product improvement and the right is reserved to modify the specifications contained herein without notice. These products have been manufactured with current technology in accordance with applicable AWWA Standards.

Kent Meters, Inc.  
P.O. Box 1852  
Ocala, Florida 34478-1852  
Local Florida 904-732-4670  
Outside Florida TOLL FREE 800-874-0890  
Inside Florida TOLL FREE 800-356-6829  
FAX: 904-366-1950

Kent Meters, Inc.  
1200 Aerowood Drive #35  
Mississauga, Ontario  
Canada L4W 2S7  
Tel: 905-238-8622  
FAX: 905-238-5840

An ABB Kent Meter Division Co.  
Distributed by:

INDT3-82-2150B-062M

# Strainers or Bag Filters: Your Choice!

F-100

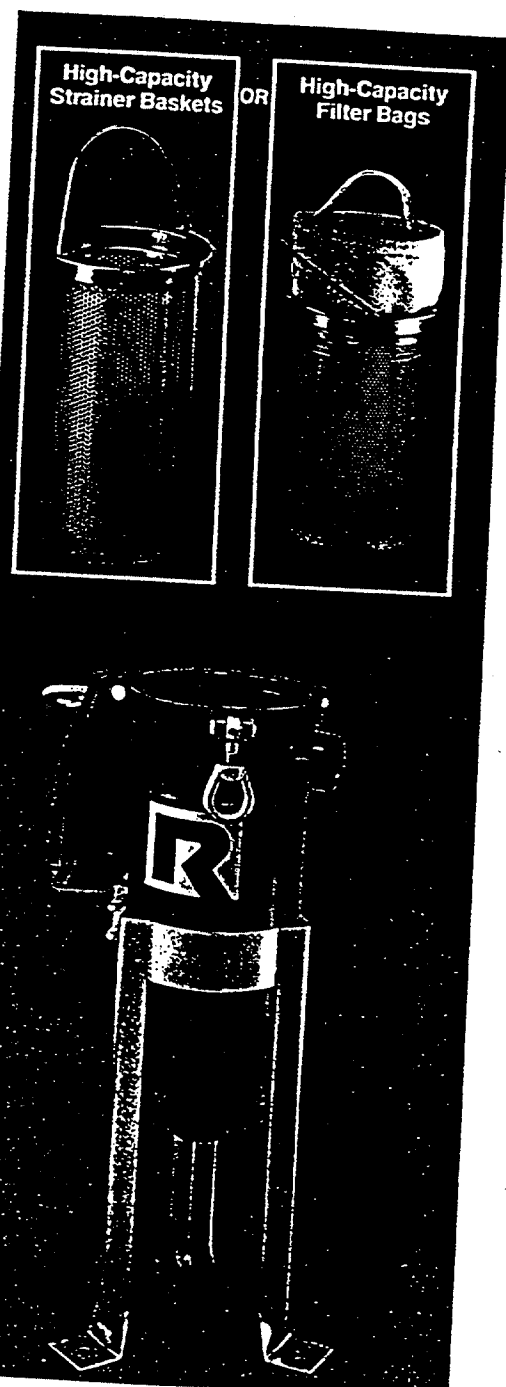
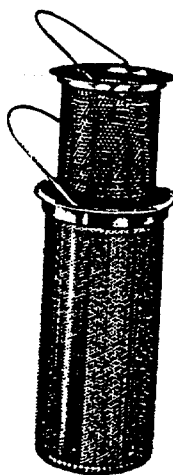
Rosedale strainer/filter housings are made in many sizes, and all can serve as basket strainers (for particle retention down to 74 micron size) or as bag filters (for particle retention down to 1 micron size). In all cases, covers are easily removed, without tools, and the basket or bag is easily cleaned or replaced.

## FEATURES

- Large-area, heavy-duty baskets
- Low pressure drops
- Housings are permanently piped
- Covers are O-ring sealed
- Carbon steel, or stainless steel (304 or 316) housings
- All housings are electropolished to resist adhesion of dirt and scale
- Adjustable-height legs, standard on Models 6 and 8; optional extra on Model 4
- Easy to clean
- ASME code stamp available
- Liquid displacers for easier servicing
- Special options include filter bag hold-down devices, sanitary construction, different outlet connections, higher pressure ratings, extra-length legs, heat jacketing, and adapters for holding filter cartridges.
- Multiple-basket and duplex units are available

## Dual Stage Straining/ Filtering

All Rosedale Model 8 housings can be supplied with a second, inner basket which is supported on the top flange of the regular basket. Both baskets can be strainers (with or without wire mesh linings) or both can be baskets for filter bags. They can also be mixed; one a strainer basket, the other a filter bag basket. Dual-stage action will increase strainer or filter life and reduce servicing needs.



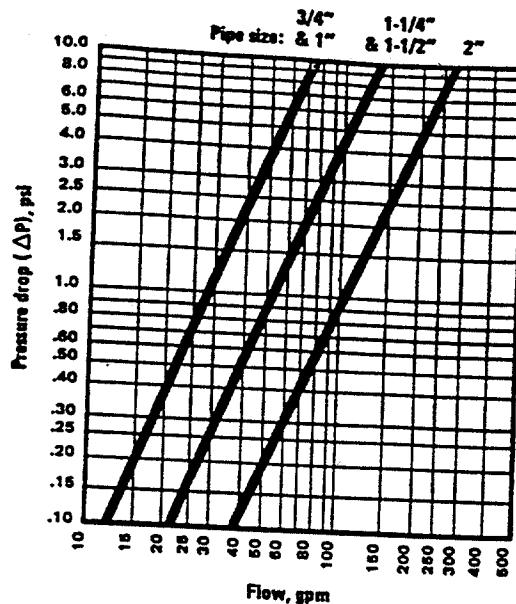
The following model descriptions and flow tables can be used to aid in selection, and make comparisons between the various styles.

#### Model 4 — For flow rates to 50 gpm\*

- Pipe sizes 3/4 thru 2-inch, NPT or flanged
- Two basket depths: 6 or 12 inches (nominal)
- Three pressure ratings: 200 psi (with clamp cover) and 300 or 500 psi (with eyenut cover)
- ASME code stamp available

##### BASKET DATA

Depth Nominal (inches)	Diameter (inches)	Surface Area (sq. ft.)	Volume (cu. in.)	Bag Size No.
6	3.9	0.5	65	3
12	3.9	1.0	130	4

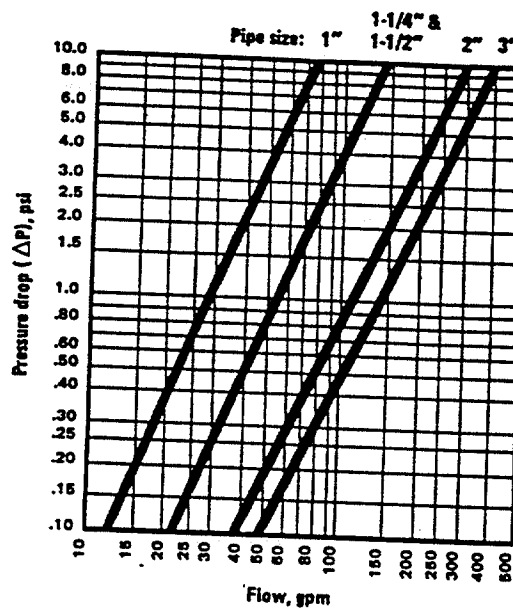


#### Model 6 — For flow rates to 100 gpm\*

- Can provide 3.4 square feet of basket or bag surface area without need for ASME code construction
- Can be fitted with cartridge filter element adapter
- Pipe sizes 3/4 thru 4-inch, NPT or flanged
- Three basket depths: 12, 18 or 30 inches (nominal)
- Four pressure ratings: 150, 210, 300, or 500 psi
- ASME code stamp available

##### BASKET DATA

Depth Nominal (inches)	Diameter (inches)	Surface Area (sq. ft.)	Volume (cu. in.)	Bag Size No.
12	5	1.3	235	7
18	5	2.0	350	8
30	5	3.4	630	9

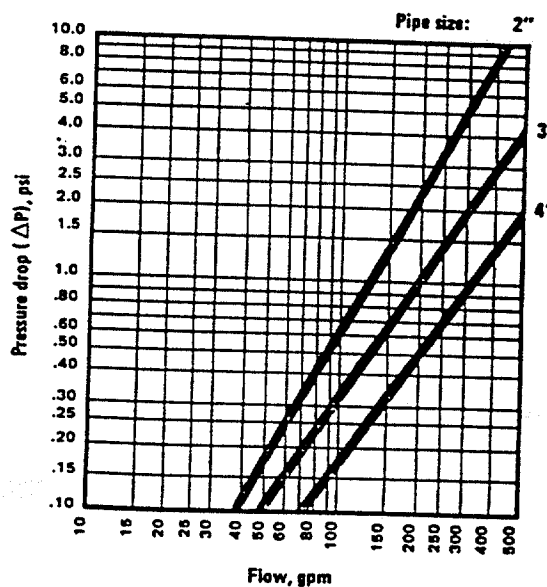


#### Model 8 — For flow rates to 220 gpm\*

- Can be fitted with an adapter to hold cartridge filter elements
- Pipe sizes 3/4 thru 6-inch, NPT or flanged
- Two basket depths: 15 or 30 inches (nominal)
- Four pressure ratings: 150, 210, 300, or 500 psi
- ASME code stamp available

##### BASKET DATA

Depth Nominal (inches)	Diameter (inches)	Surface Area (sq. ft.)	Volume (cu. in.)	Bag Size No.
15	6.7	2.3	500	1
30	6.7	4.4	1000	2

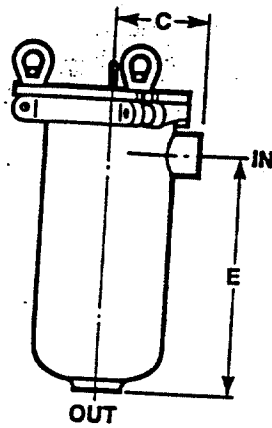
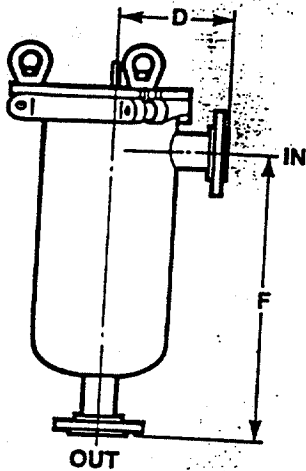


\* Based on housing only. Fluid viscosity, filter bag used, and expected dirt loading should be considered when sizing a filter.

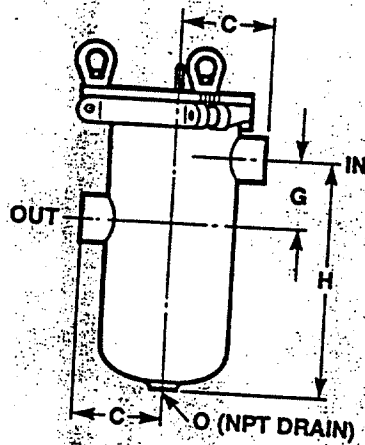
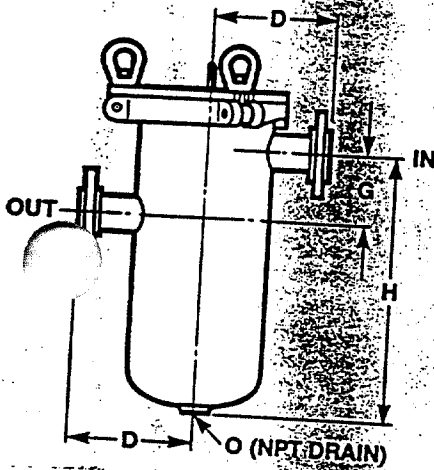
FLANGED  
(150 lb. ANSI)

THREADED  
(NPT)

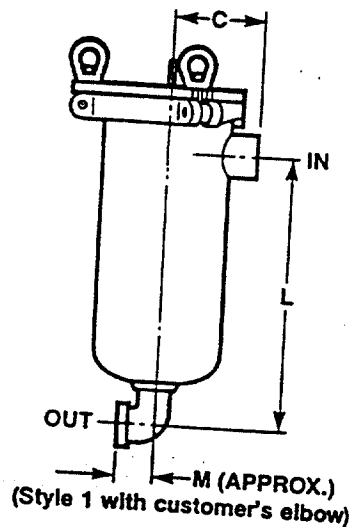
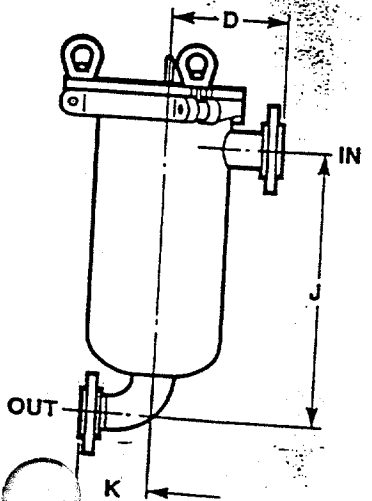
STYLE 1



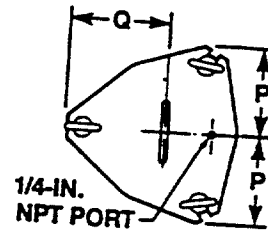
STYLE 2



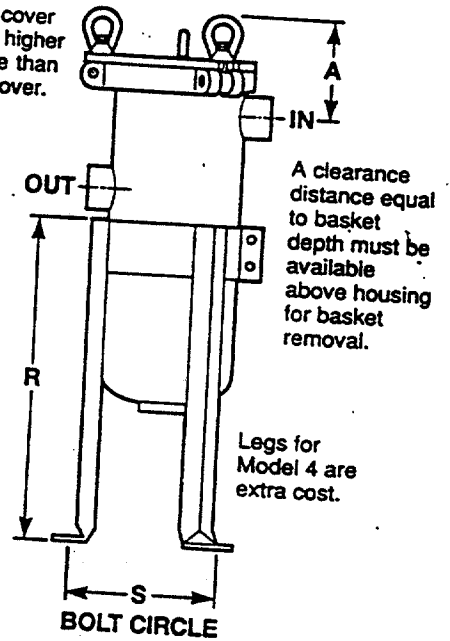
STYLE 3



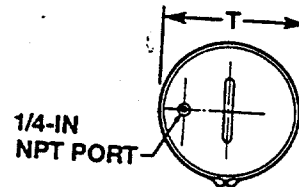
EYENUT COVER



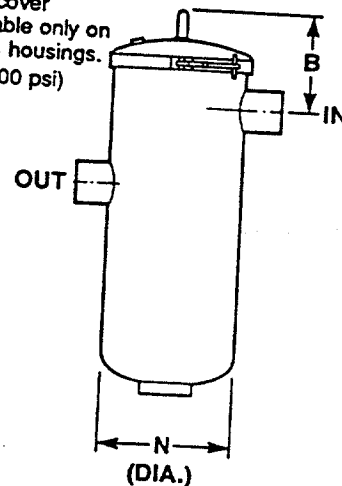
Eyenut cover permits higher pressure than clamp cover.



CLAMP COVER



Clamp cover is available only on Model 4 housings. (rated 200 psi)



Build an ordering code as shown in the example. Each option is available only on the model sizes indicated in the colored blocks preceding its description.

Key to blocks:

- 4 = Model 4  
6 = Model 6  
8 = Model 8

EXAMPLE: 8 15 3P 1 150 NCD B S - M 200 - 2M 50

#### MODEL NO.

- 4 = 4  
6 = 6  
8 = 8

#### HOUSING SIZE

- 4 6 in. = 6  
4 6 12 in. = 12  
8 15 in. = 15  
6 18 in. = 18  
6 8 30 in. = 30

#### PIPE SIZE, NPT & FLANGED<sup>1</sup>

- 4 6 8 3/4-in. female NPT = 3/4P  
4 6 8 1 in. female NPT = 1P  
4 6 8 1-1/4-in. female NPT = 1-1/4P  
4 6 8 1-1/2-in. female NPT = 1-1/2P  
4 6 8 2-in. female NPT = 2P  
6 8 3-in. female NPT = 3P  
4 6 8 3/4-in. 150-lb. ANSI flange = 3/4F  
4 6 8 1-in. 150-lb ANSI flange = 1F  
4 6 8 1-1/4-in. 150-lb ANSI flange = 1-1/4F  
4 6 8 1-1/2-in. 150-lb ANSI flange = 1-1/2F  
4 6 8 2-in. 150-lb ANSI flange = 2F  
6 8 3-in. 150-lb ANSI flange = 3F  
8 4-in. 150-lb ANSI flange = 4F  
8 6-in. 150-lb ANSI flange = 6F

#### OUTLET STYLE

- 4 6 8 Bottom = 1  
4 6 8 Side = 2  
4 6 8 Bottom elbow = 3

#### PRESSURE RATING<sup>2</sup>

- 4 6 8 300 psi = 300  
4 6 8 500 psi = 500  
4 200 psi (clamp cover) = 200  
6 8 150 psi = 150  
6 8 210 psi = 210

#### ASME CODE STAMP

- None = N  
4 6 8 Code = UM

#### HOUSING MATERIAL

- 4 6 8 Carbon steel = C  
4 6 8 304 stainless steel = S  
4 6 8 316 stainless steel = 316

#### OPTIONAL INNER BASKET

#### FOR MODEL 8 ONLY

OPTIONAL INNER BASKET, MEDIA SIZE  
No symbol if type 2B basket was selected

- 8 Perforation diameters (for type 2P baskets)  
1/4, 3/16, 9/64, 3/32, 1/16  
8 Mesh sizes (for type 2M and 2BM baskets)  
20, 30, 40, 50, 60, 70, 80, 100, 150, 200

#### OPTIONAL INNER BASKET TYPE

- 8 2B = Filter bag basket, 9/64 perforations<sup>3</sup>  
8 2P = Strainer basket, perforated metal  
8 2BM = Filter bag basket, perforated, mesh lined<sup>3</sup>  
8 2M = Strainer basket, perforated, mesh lined

#### BASKET, MEDIA SIZE

No symbol if type B basket was selected

- 4 6 8 Perforation diameters (for type P baskets)  
1/4, 3/16, 9/64, 3/32, 1/16  
4 6 8 Mesh sizes (for type M and BM baskets)  
20, 30, 40, 50, 60, 70, 80, 100, 150, 200

#### BASKET TYPE

- 4 6 8 B = Filter bag basket, 9/64 perforations<sup>3</sup>  
4 6 8 P = Strainer basket, perforated metal  
4 6 8 BM = Filter bag basket, perforated, mesh lined<sup>3</sup>  
4 6 8 M = Strainer basket, perforated, mesh lined  
4 6 8 HWM = Filter bag basket, heavy wire mesh<sup>3</sup>

#### BASKET SEAL

- 4 6 8 N = No seal (never on Models 4 & 6 bag-type baskets)  
4 6 8 S = Seal required (always on Model 8 bag-type baskets)

#### COVER GASKET

- 4 6 8 B = Buna N  
4 6 8 E = Ethylene Propylene  
4 6 8 V = Viton Fluoroelastomer  
4 6 8 T = Teflon Fluorocarbon Resin

#### DISPLACER

- 4 6 8 N = No displacer  
4 6 8 D = Displacer

1. ANSI 150-lb R.F. flanges provided as standard.  
Other styles and classes available. ANSI B16.5  
Pressure-Temperature rating tables determine flange  
class for ASME code housings. Consult factory.

2. Higher pressure ratings available.  
Consult factory.  
3. Filter bags are specified separately.  
See Rosedale Filter Bag Catalog FB.



**ROSEDALE PRODUCTS, INC.**

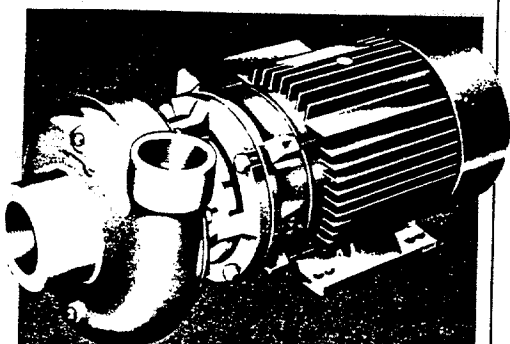
Box 1085, Ann Arbor, MI 48106

Tel: 313-665-8201 Fax: 313-665-2214

Catalog 468.5

Litho in USA

High Flow to 300 GPM  
High Head to 150 ft.



# Type ABC

## CLOSE COUPLED CENTRIFUGAL MOTOR PUMPS

Flows to 300 GPM  
Heads to 150 Feet

### MATERIALS

All Iron (AI)  
Bronze Fitted (BF)  
All Bronze (AB)  
316 Stainless Steel (SS)

### APPLICATIONS

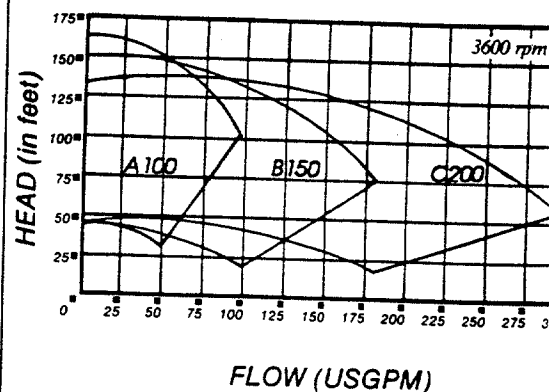
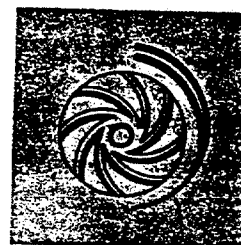
- INDUSTRY — Deionized water, water & waste treatment, various chemicals, hot solvents, caustics, some acids.
- O.E.M. — Washers, filters, chillers, cooling towers, scrubbers, plating equipment.
- AGRICULTURE — Acid fertilizers and other agricultural chemicals.

### FEATURES

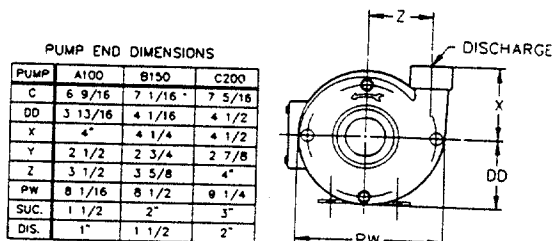
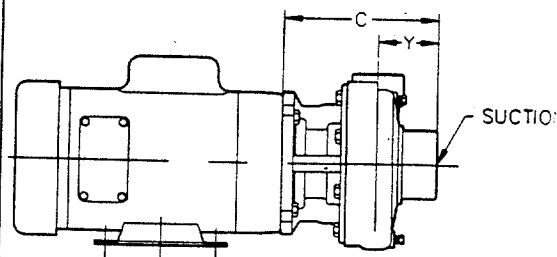
- SIZES: A100 - 1" x 1 1/2" x 6"  
B150 - 1 1/2" x 2" x 6"  
C200 - 2" x 3" x 6"
- Compact, close-coupled design.
- Standard NEMA JM motors:  
1 1/2HP thru 10HP (3600 RPM)  
1HP thru 5HP (1800 RPM)
- NEMA 'C' Face motors also available using stub shaft in place of shaft sleeve.
- Drip proof, Totally Enclosed, Fan-Cooled and Explosion-Proof motors available from stock for most models.
- Castings are heavy duty sand castings.
- Enclosed impellers for superior efficiency.
- Mechanical seal: 1 1/2" T.21 carbon vs ceramic standard. Standard elastomer is Buna for Iron & Bronze, Viton for SS pumps.
- T.9 Teflon, double seals, silicon carbide faces are among the many seal options available from stock.
- Replaceable shaft sleeve or optional stub shaft.
- Back pull-out design for easy serviceability.
- Special impeller lockscrew and Teflon gasket seals motor shaft from liquid.

### ALSO AVAILABLE

- FRAME MOUNTED
- VERTICAL
- AIR MOTOR DRIVE



Curve for reference only. See engineering curves for final select.



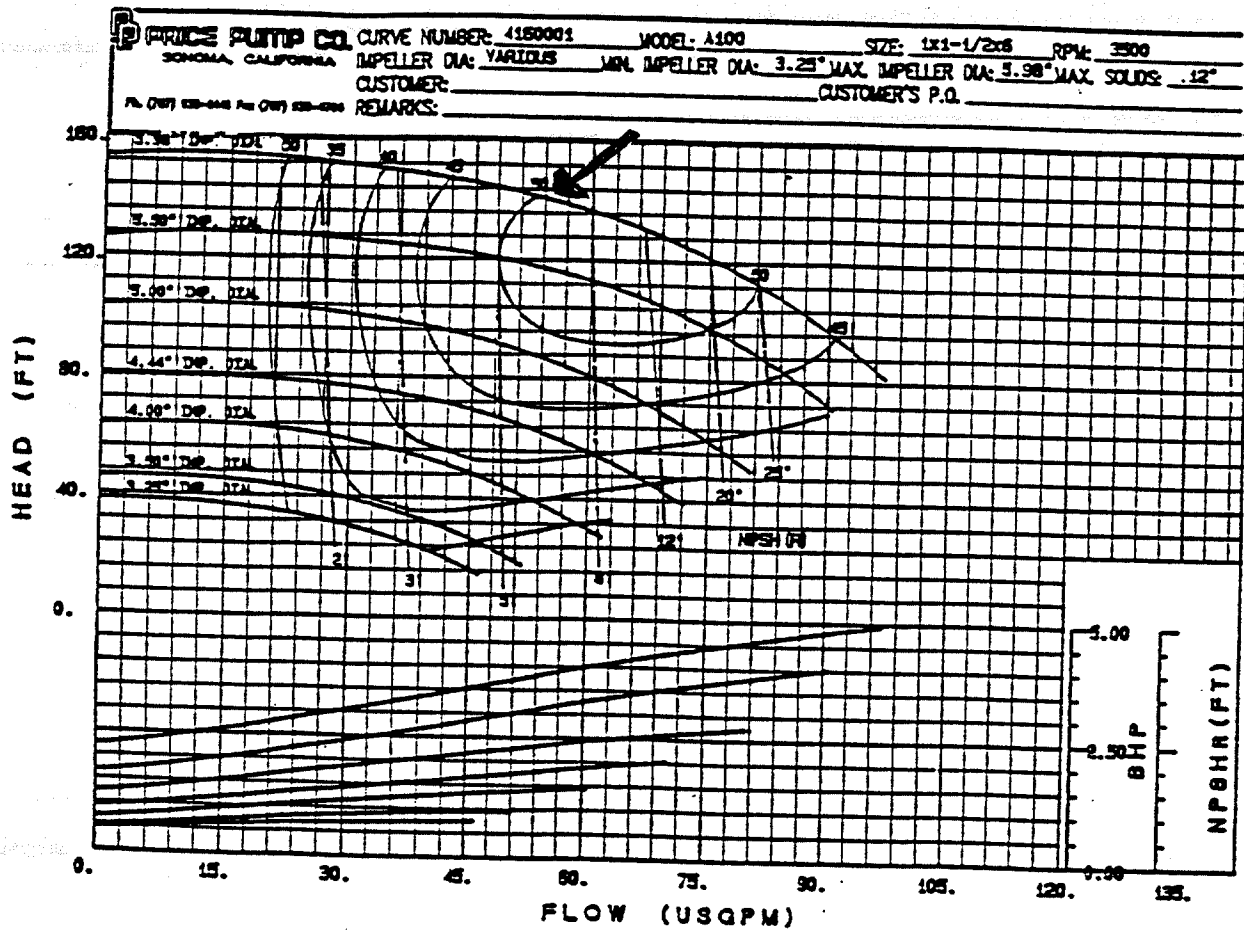
PUMP END DIMENSIONS			
PUMP	A100	B150	C200
C	6 9/16	7 1/16	7 5/16
DD	3 13/16	4 1/16	4 1/2
X	4"	4 1/4	4 1/2
Y	2 1/2	2 3/4	2 7/8
Z	3 1/2	3 5/8	4"
PW	8 1/16	8 1/2	9 1/4
SUC.	1 1/2	2"	3"
DIS.	1"	1 1/2	2"



# PRICE PUMP CO.

#1 Pump Way, P.O. Box Q  
Sonoma, CA 95476  
(707) 938-8441  
FAX: (707) 938-0764

	DISCHARGE	SUCTION
A100	1" NPT	1 1/2" NPT
B150	1 1/2" NPT	2" NPT
C200	2" NPT	3" NPT

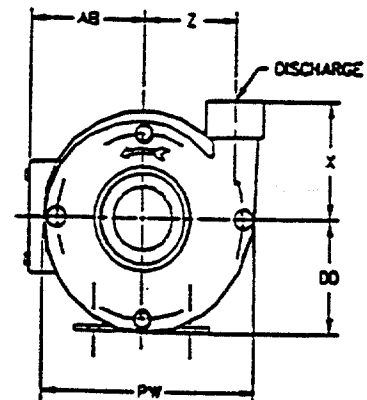
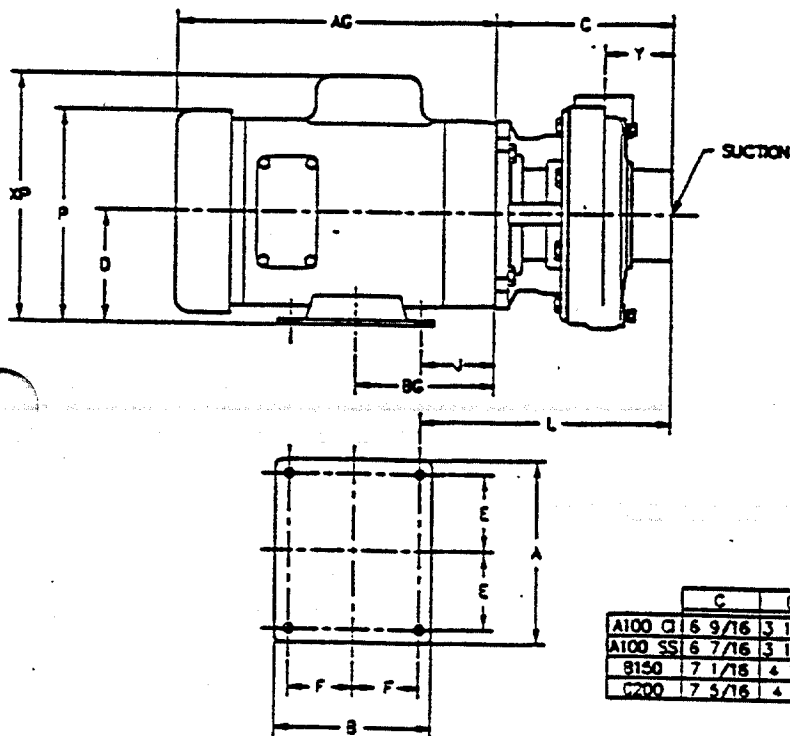




PRICE PUMP CO.

# ABC OUTLINE DRAWING

Effective: January 1, 1993



PUMP END DIMENSIONS

	C	DO	J	X	Y	Z	PW	SUCTION	DISCHG
A100 G	6 9/16	3 13/16	7"	4	2 1/2	3 1/2	8 1/16	1-1/2"	1"
A100 SS	6 7/16	3 13/16	6 7/8	4	2 3/8	3 1/2	8 1/16	1-1/2"	1"
B150	7 1/16	4 1/16	7 1/2	4 1/4	2 3/4	3 5/8	8 1/2	2"	1-1/2"
C200	7 5/16	4 1/2	7 3/4	4 1/2	2 7/8	4	9 1/4	3"	2"

MOTOR END DIMENSIONS

	AG	AB	BG	E	F	J (REF)	N DIA.	B	L	A	O	XP	P
A100-150	11 1/4	5 1/4	4 7/8	2 3/4	2	2 7/8	11/32	5 15/16	10	6 1/2	3 1/2	9 1/8	6 7/8
A100-200			5 3/8		2 1/2								
A100-300	12 1/8	5 1/4	5 3/8	2 3/4	2 1/2	2 7/8	11/32	5 15/16	9 1/4	6 1/2	3 1/2	9 1/8	6 7/8
A100-500	13 13/16		5 1/4		2 3/4								
B150-150	11 1/4	5 1/4	4 7/8	2 3/4	2	2 7/8	11/32	5 15/16	9 1/4	6 1/2	3 1/2	9 1/8	6 7/8
B150-200			5 3/8		2 1/2								
B150-300	12 1/8	5 1/4	5 3/8	2 3/4	2 1/2	2 7/8	11/32	5 15/16	9 1/4	6 1/2	3 1/2	9 1/8	6 7/8
B150-500	13 13/16		5 1/4		2 3/4								
B150-750	15 5/16	5 7/8	6 1/4	3 3/4	2 3/4	3 1/2	13/32	6 1/2	9 7/8	8 1/2	4 1/2	10 11/16	8 7/16
C200-150	11 1/4	5 1/4	4 7/8	2 3/4	2	2 7/8	11/32	5 15/16	10 7/8	6 1/2	3 1/2	9 1/8	6 7/8
C200-200			5 3/8		2 1/2								
C200-300	12 1/8	5 1/4	5 3/8	2 3/4	2 1/2	2 7/8	11/32	5 15/16	11 1/2	8 1/2	4 1/2	10 11/16	8 7/16
C200-500	13 13/16		5 7/8		2 3/4								
C200-750	15 5/16	5 7/8	8 1/4	3 3/4	2 3/4	3 1/2	13/32	6 1/2	11 1/2	8 1/2	4 1/2	10 11/16	8 7/16
C200-1000	15 9/16	7 5/8	7 1/4	4 1/4	2 3/4	4 1/2	13/32	8	12 1/2	9 1/2	5 1/4	N/A	10 1/16

1. DIMENSION "XP" APPLIES TO SINGLE PHASE MOTORS ONLY.  $\Delta$

Price Pump Company

31 Pump Way • P.O. Box 0 • Sonoma, CA 95476 • (707) 938-2441 • Fax (707) 938-0764

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